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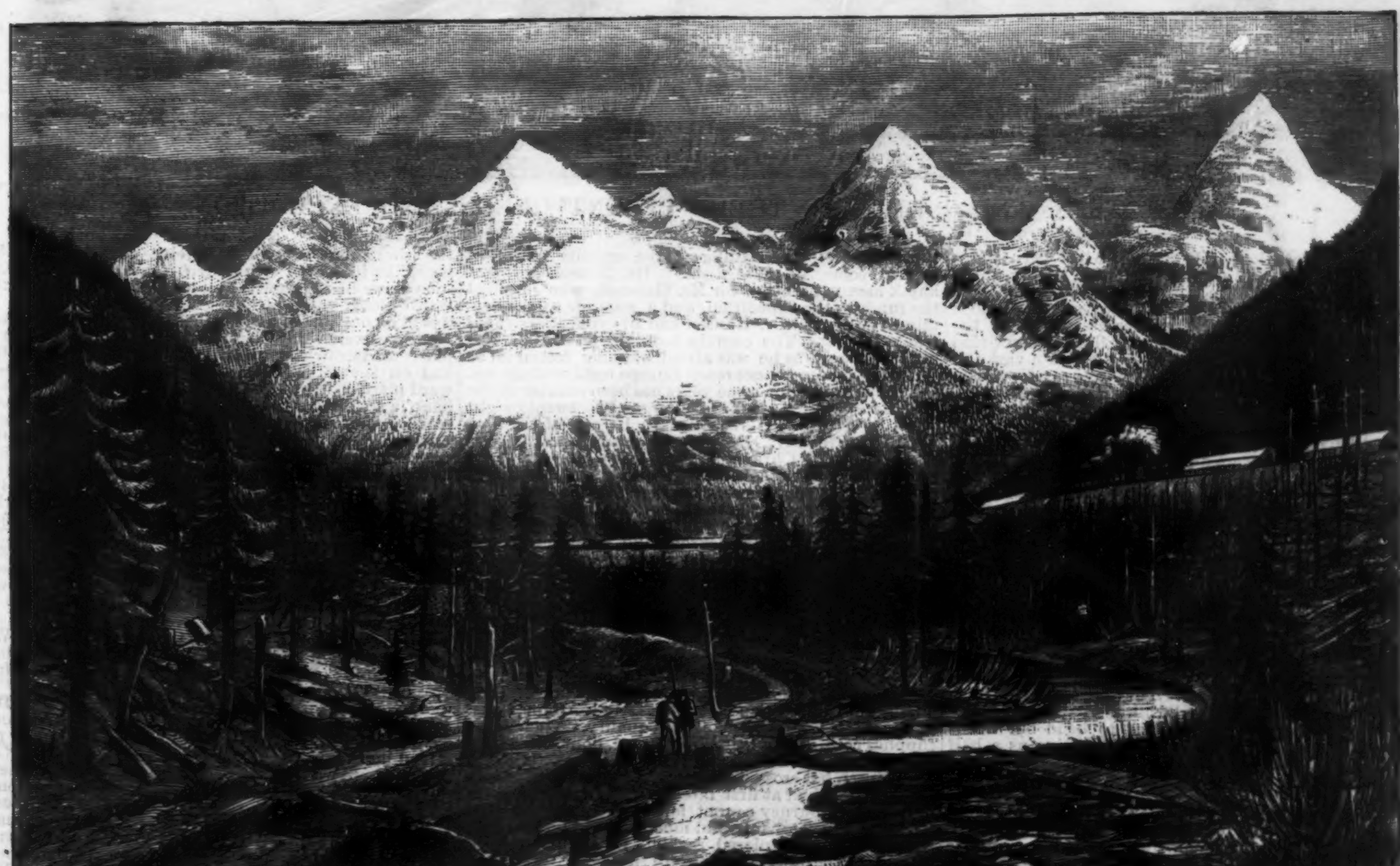
MOUNT STEPHEN, EAST SIDE—ROCKY MOUNTAIN RANGE, BRITISH COLUMBIA.



THE CANADIAN PACIFIC RAILWAY—SELKIRK MOUNTAIN RANGE, NEAR THE GLACIER HOUSE AND THE LOOP, BRITISH COLUMBIA.

CANADIAN PACIFIC RAILWAY, BRITISH COLUMBIA.

OUR special artist, Mr. Melton Prior, in choosing subjects for his sketches of the long railway line from Montreal to Vancouver, nearly three thousand miles, has preferred the wild and romantic highland scenery of British Columbia to the vast plains that extend from Winnipeg to the foot of the Rocky Mountains. The railway station called Stephen is 5,200 ft. above the sea level, and here the waters begin to flow in two opposite directions; the streams running eastward having to join either the Athabasca or the Saskatchewan, and the latter finally to be discharged into Lake Winnipeg and Hudson's Bay; while those of the westward slope meet with the Columbia River, the Fraser River, or the Thompson River, whose issue is in the Pacific Ocean. Mount Stephen rises 8,240 ft. above the railway.

Passing from Stephen down the tremendous ravine of the Kicking Horse, with a gradient of 220 ft. to the mile, the Columbia River is reached and crossed, and behind its valley rises another jagged and formidable range, the Selkirks, which are the second of the four mountain ranges that separate the plains from the Pacific Ocean. The ascent of the Selkirks is begun by a gradually rising line along the sides of the high embankments which inclose the beautiful valley of the Beaver River. The engineering to bring the line from the vale to the heights is admirable. A bridge 1,200 ft. in length is crossed in one place; in another, a trestle 295 ft. above a mighty torrent sweeps for 750 ft. in a graceful curve; at every minute the train passes over some splendid structure which resists or overleaps the force of mountain floods and avalanches. For miles one sees new bridges, and in the gulch far below them the wrecks of splintered wood and twisted iron which show where slides of rock and ice destroyed the line in the winter before the points of danger had been learned. Now, huge bulwarks of rock and timber, sheds and tunnels insure the prevention of another such mischief. The summit reached, we see prodigious mountains rising a mile in sheer ascent beside the track, and at Rogers we pass two lines of snow-clad peaks, of which that on the right incloses a vast amphitheater whose walls rise 9,000 ft. above the valley, and inclose a glacier of shining green, blue, and white, with which none in Switzerland is to be compared in size and beauty. Down the western slope the train runs by an imposing system of loops, which, coiling the track about as if it were a pile of rope, stretches nearly seven miles to gain two miles in distance and a few hundred feet in elevation. "The scenery now," says a writer, "is grand beyond the power of language to paint. One glacier forms upon another. To our right we pass the summit, and two miles on reach Glacier House, a beautiful Swiss chalet, in front of which are beautiful fountains throwing up icy streams. Here, apparently a few hundred yards away to our left, is a monster glacier with its foot not far above the level of the road. With a glass, we see mighty fissures cracking its surface. It bends over the mountain like a falling curtain. We are told it is a mile and a half wide, nine miles long, and 500 feet deep. Mount Sir Donald is watching its slow descent. Far above the snow, his peak, shaped like a diamond drill, pierces the blue sky over 6,000 feet above us. We have to bend our heads back to look upon his pinnacle. They give us a half hour to look, and eat a first rate lunch."—*Illustrated London News.*

WOOD pulp is found to be adapted for making pipes with iron couplings to convey any fluids not strongly alkaline or of very high temperature. It is impervious to leakage or attacks from any thing in the earth of cities. It is specially suited for carrying water and illuminating or natural gas. Its non-conducting properties make it just the thing for storage and galvanic battery jars, and for underground wire conduits.

ACROSS GREENLAND ON SNOW SHOES.

MUCH relief has been felt at the safe accomplishment by Dr. Frithiof Nansen, the adventurous Norwegian naturalist, and his companions, of their perilous journey across Greenland. Since the little party left the Norwegian whaler Jason, on July 17, when they were deposited on the ice-rim outside the Sermilik fjord, on the east coast of Greenland, at about 65 deg. 30 min. N. latitude, nothing whatever had been heard of them until news was brought by the steamer Fox, from Ivigtut, that Dr. Nansen had arrived at Godthaab, on the west coast, on October 3. It appears that, when placed on the ice-rim, they were unable to reach land for twelve days, owing to screwing ice and whirlpools, through which it was impossible to cross, but they were eventually able to land at Andretok, north of Cape Farewell, and about 61 deg. N. latitude, and then, going further northward, they reached Uminik, from which point they began their journey on August 15. Dr. Nansen at first directed his course toward Christianshaab, but subsequently made for Godthaab. Some snowstorms and much heavy ground were experienced, and a height of 10,000 feet was attained—the temperature being 40 to 50 degrees below zero (Centigrade). For several weeks the party remained at an altitude of over 9,000 feet, their progress being hindered by tremendous storms and loose snow.

Toward the end of September they reached the western coast above Godthaab, and thence had a perilous descent on ugly and uneven ice, but, eventually, reached the Ameralik fjord safely. There they managed to build a kind of boat from the floor of the tent, bags, bamboo reeds, and willow branches, and in that frail craft Dr. Nansen and a seaman named Sverdrup rowed along the coast to Godthaab, leaving their four companions, for the time, at Ameralik. The last steamer had left Godthaab for the winter, but hearing that the Fox was loading at the cryolite mines at Ivigtut, some 300 miles distant, Dr. Nansen sent two kajak men with letters for Mr. Gammel, who supplied the funds to the expedition, and a message to the captain to wait until Dr. Nansen and his colleagues could reach Ivigtut. The captain took the letter, but was unable to wait, as he was afraid of being frozen in, so that Dr. Nansen cannot reach Europe until next spring. Dr. Nansen, who for some years has been curator of the Old Hanseatic Museum at Bergen, is twenty-eight years of age, and is reckoned to be one of the best athletes in Norway. He was the champion *ski* (snow-shoe) runner of Christiania, and last winter prepared himself for this expedition by crossing the Norwegian mountains on snowshoes, dragging a sledge after him, and sleeping in a bag in the open air. In the present expedition he was accompanied by three Norwegians, Messrs. Sverdrup, Dietrickson, and Kristiansen, and by two Laplanders, Ole Ravna and Samuel Baltor—all, with the exception of the first named Lapp, being about thirty years of age. The expedition, which, as we have said, was fitted out chiefly at the expense of a wealthy Danish merchant, Mr. A. Gammel, took with them all the usual appliances for Arctic travel, though in as concentrated a form as possible. These consisted of five light sledges, a light boat on runners, twelve pairs of Norwegian *ski*, several pairs of Canadian and Norwegian snowshoes, and Alpine ropes of the best English make and quality. Their food supplies consisted of dried beef, bread, flour, chocolate, etc., but no alcoholic stimulants whatever. Though Dr. Nansen has crossed Greenland at a much lower latitude than he had at first intended, the experiences of his perilous journey cannot fail to be highly interesting, and will probably add much to our knowledge of that hitherto unexplored region. Our illustration is from a photograph taken before the departure of the expedition. It shows the expedition in their traveling costumes, and their sledges, *ski*, and Canadian snow shoes, Dr. Nansen being seated in the center.—*London Graphic.*

DR. NANSEN AND PARTY ON THEIR RECENT GREENLAND EXPEDITION.

NANSEN'S GREENLAND EXPEDITION.

THE last mail from Norway brings more information about the Nansen expedition to the interior of Greenland. The expedition consisted of the following named daring men, under the leadership of Dr. Frithjof Nansen, conservator of the Bergen Museum: Lieut. Olaf Dietrichsen, Mate Otto Sverdrup, Christian C. Trana, Ole N. Ravna, and Samuel J. Batto, all especially selected men, strong and healthy in body and mind and good "ski-runners." "Ski" are the snow shoes extensively used in Norway for traveling over the snow fields of that country. The party left Norway on May 2; traveled by steamer as far as to Iceland, where they arrived in the middle of June. From Iceland the whaler Jason brought them over to Greenland, and on the 17th of July left them on the drifting ice with the land in sight some few miles distant. From that time until they could reach the inhabited west coast of Greenland, communication with the rest of the living world would be an absolute impossibility. A stretch of 450 miles, never traversed by man, lay before them; they had their Norwegian ski, provisions for two months, and necessary instruments for making observations, and they started for the shore. They had to make their way across the glaciers in two months or die. Not before next summer can we have a complete report of the journey; till then we must be content with the information we get from two hurriedly written letters which, by mere accident, came over in the last vessel from that region this year. The letter from the mate Sverdrup to his father is given below:

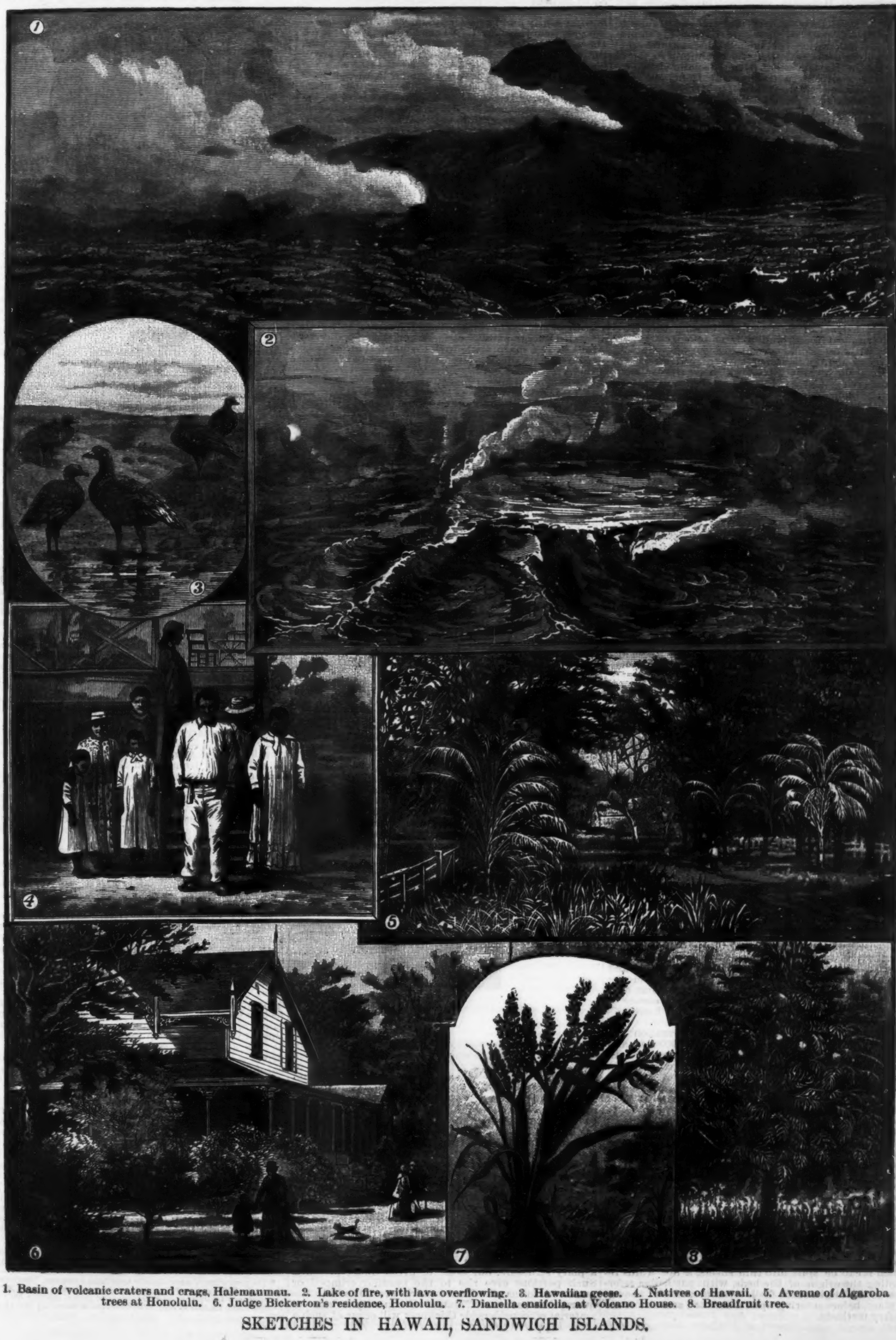
"GODTHAAB, Oct. 4, 1888.

"Yesterday, after sixty-four days' journey from the east coast, we arrived here all safe. The landing was more difficult than we had calculated. The drifting ice upon which we stepped when leaving the whaler was moving very rapidly toward the south and off from the shore, and it took us twelve days to reach the shore. In that time we had drifted nearly 100 miles. As soon as we had terra firma under foot we started northward along the coast, looking for a place where it would be possible to ascend the solid inland ice. After another twelve days' search we finally found such a place, made our way up without very great difficulty, and on the 16th of August we commenced our westward march. We at first laid our course for Christianshaab (a settlement to the northwest), but when we had reached an elevation of about 7,500 feet a terrible snow storm met us, and we concluded to take a more southerly direction toward the Godthaab settlement, as this line would be shorter, and probably would not expose us so severely to the storms from the north. We had, indeed, a hard journey. The terrain in general and the snow were very difficult to walk upon, and the weather was rough. In about three weeks we traveled on an elevation of 10,000 feet in a temperature of 35° to 40° below zero; but we kept moving. Only four days were we held by storms. When we came across and down from the inland ice on the west side, we found a stretch of about twenty miles wide free from snow, fifteen miles of which was along the edge of a fiord. We brought the tent and provisions down to the shore and built a camp; further proceeding seemed for a time impossible. Then we made a small boat from part of the tent and a canvas bag. When this boat was ready Dr. Nansen and I started for this place, and after four days' rowing we arrived here, and were very kindly received by the people. Two boats are now sent to the camp, where we left our companions, to bring them down here. The post ship has left long ago, but some fifty miles farther south there is a steamer, having been accidentally kept back by a breakdown and the storms, now just ready to sail for Copenhagen, and we send two messengers, hoping they will reach the steamer, and perhaps make it wait for us and take us home. We have but very little hope, though, that the steamer will wait, and we shall be compelled to stay here over winter, as this is the last chance this year."

It appears that the steamer did not wait for them, but took the letters and delivered them at Farsund, the nearest port in Norway. The expedition, consequently, must stay in Greenland through the winter, with the prospect of getting plenty of leisure time, and next summer we shall have a full report of this remarkably daring and interesting journey.—*Amer. Naturalist.*

THE VOLCANIC REGION OF HAWAII.

WE have to speak of that interesting group of islands, half-way across the Pacific Ocean from the western coast of Mexico to the Chinese Archipelago, in the 20th degree of latitude north of the equator, which forms the native Kingdom of Hawaii. The name belongs to the whole of the small nation, now dwindled to 70,000, inhabiting the larger island, Hawaii proper, the island of Oahu, which contains the capital and well-known commercial port of Honolulu, and the islands of Maui, Molokai, Lanai, Kauai, and Nihau, with many smaller isles of no account. These were formerly called the Sandwich Islands—after their discovery by Capt. Cook,



1. Basin of volcanic craters and crags, Halemaumau. 2. Lake of fire, with lava overflowing. 3. Hawaiian geese. 4. Natives of Hawaii. 5. Avenue of Algaroba trees at Honolulu. 6. Judge Bickerton's residence, Honolulu. 7. Dianella ensifolia, at Volcano House. 8. Breadfruit tree.

SKETCHES IN HAWAII, SANDWICH ISLANDS.

who met his death by the spear of a savage at Hawaii, the name being spelt "Owhyhee" in old books of geography and travel. Since 1819, the ruling class of natives have professed Christianity, and some progress has been made in civilization. King Kalakaua, and Queen Kapiolani, and the ex-Queen Emma, who are educated persons and have traveled in Europe, are no strangers to good English society. The Anglo-American colony at Honolulu, including missionaries and teachers of every Protestant religious denomination, enjoys the royal favor and exercises a beneficial influence. But our purpose just now is especially to present a few illustrations of the amazing natural phenomena of volcanic action in the mountain region of the island of Hawaii, which is not usually visited by those who sojourn for a few days at Honolulu. For these illustrations we are indebted to Mr. Scott B. Wilson, a scientific and practical botanist and naturalist, well known to the Zoological Society of London, we believe, and to the Natural History Museum; who, in September and October, 1887, explored the great volcano of Kilauea, and took a series of photographic views. He sent us also views of the neighborhood of Honolulu, with several specimens of the peculiar vegetation, the algaroba, the bread fruit tree, and the "Dianella ensifolia," belonging to these islands, and portraits of the Hawaiian native people.

The best description of the volcanic region of Hawaii is to be found in Miss C. F. Gordon-Cumming's book, "Fire Fountains," published in two volumes by Messrs. W. Blackwood & Sons in 1883—a work of great interest, written in a vigorous and agreeable style, and containing valuable information concerning the principal islands, the kingdom and its inhabitants, and their manners and customs, as well as these wonders of nature. The mountains, of which the highest summit, Mauna Loa, has an elevation of 14,000 ft., are approached by a very gradual ascent from the seashore at Hilo, a journey of thirty miles. Passing through a belt of tropical forest and a tract of coarse grassy downs, with occasional swamps, one comes upon a great rocky plain intersected by hardened streams of black lava, the huge blocks of which are strewn about the country for many miles. At an elevation of 4,000 ft. lies the immense active crater of Kilauea, the largest in the world. It is a huge sunken pit, nine miles in circumference, the walls of which, 600 ft. deep, are precipitous, and the bottom, of a bluish gray color, is a floor of hot lava; in its center is the Lake of Fire, called Halemaumau, inclosed by a circle of high crags, ever and again changing their shapes as fresh masses of molten lava are thrown up from beneath. This, however, is often concealed by the dense clouds of steam continually arising; it is only by the aid of a favorable wind that, from some point or other, a distinct view of the crater may be obtained. The abyss, of unknown depth, is filled with flames or waves of fire, which at night cast an awful reflection on the clouds of vapor; but this is only at the time of an active eruption. There are times when the fire recedes into the earth, and Miss Gordon-Cumming, with her guides and companions, was then able to descend into the pit, and to walk over the ridges and billows of lava crust, to climb the inner circle of crags, and to look down into the crater, where she saw only steam and smoke, with frequent jets and flashes of bluish fire, and a sort of fire-spray—now white, now glowing red, now yellow—licking the sides of the rocks. The continual alternations in the internal condition and in the aspect of Halemaumau, and likewise of Mauna Hua-lei-lei, which has twenty craters—one a mile in circumference, the others much smaller—are to be remembered in comparing the accounts of different travelers. A crater usually finishes by forming a perforated cone of lava which rises from the bottom of its pit, and which may be 500 ft. high. Miss Gordon-Cumming, on a second visit to Halemaumau, saw the new formation of many such cones and domes, a new lake and new rivers of liquid lava, where she had been able to walk in safety not many days before. The other celebrated volcano, Mauna Loa, with its creater, which is called Mokuaweo-weo, near the summit, differs considerably from Kilauea, and is not always in action; but its notable eruptions from 1789 to 1877, of which an historical account has been compiled by the Rev. Titus Coan, especially the great eruption of 1868, and the later tremendous outburst in 1880 and 1881, are famous enough.—*Illustrated London News.*

AMONG THE PENNSYLVANIA SLATE QUARRIES.

By GEORGE P. MERRILL, Curator in the National Museum at Washington.

THE belt of territory, from eight to twelve miles in width, which is colored on the maps of the Pennsylvania State Survey as occupied by rocks of the Utica and Hudson River slate formations, and which from the Delaware River on the east extends in the form of a broad curve entirely across the southeastern corner of the State into Maryland, carries within its limits the largest slate-producing centers of America.

Although the entire thickness of the formation has been variously estimated at from 3,000 to 6,000 feet, and it runs in a continuous belt close to and parallel with the Blue Mountains through Northampton, Lehigh, Berks, Lebanon, Dauphin, Cumberland, and Franklin Counties, but a small part of the rock is sufficiently fissile and homogeneous in color and texture to be of value for roofing or other of the numerous purposes to which slate is commonly applied, and at the present time the quarry industry is sufficiently developed only in the two counties first named to merit our attention. The active exploitation of the material in these two counties has given rise to a considerable number of small towns dependent wholly upon the industry for their subsistence, and which are suggestively named Slatington and Slatedale, or after their Welsh predecessors and counterparts, Bangor, Penrhyn, Pen Argyl, etc.

Slate quarrying is stated to have been begun in Pennsylvania by a Mr. J. W. Williams, at Slatedale, about the year 1812. As, however, the utility of the stone is dependent almost wholly upon the facility with which it can be split into thin sheets, a few words regarding the origin of the beds, with particular reference to the origin of the fissile structure, may not be out of place, before entering upon a detailed account of the quarry methods.

Common slate is but an indurated clay. It originated as a deposit of fine silt on some ancient sea bottom. Such deposits, gradually accumulating through long years, would be thrown down in parallel and approximately horizontal layers, but individual layers would naturally vary somewhat in texture and perhaps color, according as the tributaries by which the silt was borne down to the sea periodically varied in the rapidity of their currents, a swift, turbulent stream carrying down more and less finely assorted material than one flowing gently and in lesser volume. In the course of the ages following, the beds thus deposited were lifted above the water and, by means of lateral pressure, thrown into a series of long parallel folds, which are in places turned completely over upon one side.

Overturned folds are very common in the quarries about Bangor. If the reader will lay together on the table before him a few sheets of paper to represent the layers of fine and coarse clay, as it was first deposited, and then, by pushing from each end toward the center, will cause them to rise in a fold or arch at the middle, and, lastly, will lay this fold on its side, he will gain a very correct idea of what has taken place here.

Formed in this manner, it would be but natural to suppose that the very decided tendency to cleave into thin, smooth sheets would be developed always parallel with this ancient bedding. Such, however, is far from being the case. Indeed, as a rule, the fissile structure is developed at very considerable though ever varying angle with the bedding, and is in no way connected with it genetically. In the case mentioned the splitting is directly across the apex of the fold, and corresponds therefore with the bedding at the two sides (above and below), but crosses it at all angles at intermediate points.

To what, then, is this fissility due, and how is it to be accounted for? The fact that a mass of stone will split up indefinitely into sheets sometimes less than one eighth of an inch in thickness, and into plates of large size, with smooth parallel surfaces, and this, too, directly across or at a sharp angle with the natural grain, is indeed a remarkable feature and one worthy of careful study.

A common feature of many, indeed of most, slates is the presence of bands of varying width and color, usually darker, running across the cleaved surface. These, which occur at varying intervals, from less than an inch to a few feet, are technically called *ribbons*, and represent the original lines of bedding, are due, in fact, to the dissimilarity of the materials deposited at the various stages of high and low water during the slate-making process. But, as already noted, the slate cleaves with great readiness at varying angles with these ribbons, while it breaks only with the greatest difficulty, and with ragged and wavy lines, in a direction parallel to them, or to the original bedding, which is the same thing.

This is explained as follows: In Fig. 1 we will suppose the horizontal lines to represent the fine clayey sediment as it was first lain down on the bottom, and the broken lines material of a trifle different consistency or color. Now if, while the clay was still more or less plastic, a gradual but very powerful pressure was brought to bear from the directions indicated by the arrows, there would be produced first a considerable shortening in this direction, and secondly, as has been proved by actual experiment, a decided fissile structure in a direction at right angles with the direction of pressure, or in a vertical direction in this case, as shown in Fig. 2. A fold might or might not be produced at the same time.

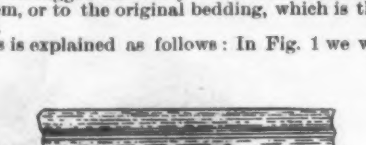


Fig. 1

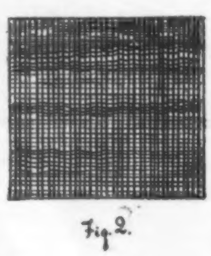


Fig. 2.

This property of substances to cleave or assume a platy structure when pressed, rolled, or pounded is shown in the flaking of pastry or the exfoliation of rails subjected to the continuous hammering of car and engine wheels. The Penobscot or Passamaquoddy Indian takes advantage of a similar property in woods, when he separates from an ash log long, thin strips of basket material by merely pounding along the log with the back of his ax. The effects of this lateral pressure upon the internal structure of the rock is beautifully shown by cutting a very thin section from the slate parallel to the face shown in Fig. 2, *i. e.*, across the cleavage, and examining it under a microscope of high power, when it will be seen that all the minute fragments originally lain with their longer axes horizontal have reversed their position, and now lie with their shorter axes in the direction of pressure, as I have attempted to show in Fig. 3, drawn from a thin section of slate under a magnifying power of some fifty diameters. It frequently happens, however, that certain layers of the slate are not of such a nature as to readily assume a platy structure, but bend or break under pressure. Such portions give rise to the peculiar crimped or puckered forms of ribbons which are known to the quarrymen as "curly" slates. Frequently a layer of material of considerable thickness will occur of such a nature as to completely resist all attempts on the part of Dame Nature to produce the desired fissile structure, but will bend or break repeatedly, or sometimes remains as a hard, compact, homogeneous mass, while the slates above and below assume the normal form. Since, in preparing the quarried material for roofing purposes, all such non-fissile or curly or cramped portions must be rejected, the processes of slate manufacture are enormously wasteful, and the entire country in the vicinity of the quarries is covered by huge piles and ridges of debris, on the extreme outer edges of which are precariously pitched, at every conceivable angle, the long line of splitters' shanties.* Within a few years this slate waste has been utilized to some extent for brick making, but the demand is not yet sufficient to make appreciable inroads on the supply. The slate is finely pulverized, mixed into a clay, moulded, and baked like an ordinary brick. The result is a trifle more porous texture and duller color than the clay brick, but is said to be good and durable.

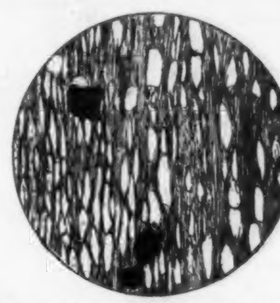


FIG. 3.—CROSS SECTION OF SLATE.
(× 50 diameters.)

The slates, with the single exception of the Franklin quarries at Slatington, are mined from open quarries. These are in some cases mere pits, one hundred or more feet in depth, with vertical or even overhanging walls, and accessible only by means of a windlass or cable derrick. Others, like the Bangor quarry, cover an acre or more of ground, and, though 200 or more feet in depth, have graded roadways allowing the passage of teams to the very bottom. At the quarry just mentioned, a small locomotive with cars is employed to carry the slate from the mouth of the quarry to the desired points. As a rule, the quarries are worked by contract, from four to six men together taking a contract, to quarry and split the slate at a stipulated price, the owners doing the hoisting and hauling. The machinery and tools used are few and simple, consisting of derricks, waste boxes, drills, hammers, crowbars, sledges, splitting chisels, and dressing machines. Steam drills are used in a few instances. In opening a new quarry, after the dip and general position of the bed have been determined, the weathered surface material for a depth of twenty feet or so is removed by pick and shovel, aided, if necessary, by blasting. When sound material is struck it is loosened by blasting in as large blocks as can be readily handled, the holes being drilled almost altogether by the old hand process and as nearly at right angles with the cleavage as circumstances will permit. The loosened blocks are then hauled to the surface by means of the ordinary spar or cable derricks, the latter being preferable, and most generally employed. This is of the type ordinarily used in mining from deep pits, and consists of a fixed wire cable passing over pulleys set upon a post at the edge of the quarry opening and passing down at an angle to fasten upon the opposite quarry wall. Over this fixed rope a traveler passes. This traveler consists of an iron frame, with three or four wheels, the hoisting rope passing through the lower wheels, while the upper wheels travel over the fixed rope. The hoisting is done by means of engines, of from thirty to forty horse power, the cables passing over large drums controlled by friction clutches. The traveler is often spoken of locally as a "Blondin." The reason for this is obvious.

The block of slate, after being loosened from the quarry bed and brought to the surface, is put upon a truck or push car and taken immediately to the splitter's shanty, where it is taken in charge by a "splitter" and his assistants. If the block is to be worked up for roofing or school slates, the method of procedure, as given by F. Prime, Jr., in the reports of the Pennsylvania survey, is substantially as follows: The block is first taken in charge by one of the splitter's assistants, who, with hammer and chisel, cuts it into blocks of suitable size for splitting into slates. These blocks are about two inches thick and of sufficient surface to be capable of being dressed into finished slates of the various sizes. Supposing the block, as it comes from the quarry, to be one foot thick, eight feet long, and four feet wide. This first assistant, called a "bank" man, takes a hammer and chisel, and cuts a notch some three to six inches deep into the middle of the block at the end; then with a large wooden mallet he drives a chisel into the end of this notch, watching carefully the direction the crack takes. If it goes parallel with one of the sides, he continues; if not, by using the mallet on one or the other sides of the notch he brings it back toward the proper direction. After he breaks the block lengthwise into two, he then cross-cuts it in the same manner into four pieces. Both of these breaks, it should be borne in mind, are across the cleavage of the slate. He then, with a flat chisel, splits parallel with the cleavage each one of the foot thick blocks through the middle, repeating the process until they are reduced to a thickness of about two inches, when they are piled up for the splitter. The splitter takes each block and, by means of a broad, thin chisel, splits them through the middle, and continues dividing them into equal halves until they are reduced to the required thinness for roofing or for school slates. These thin slabs with their very irregular edges are then taken by another assistant and squared off into regular sizes by means of a dressing machine.

* The proportion of waste slate is sometimes enormous. Davies states that in the Welsh quarries 16 or 20 tons of waste to one of merchantable material is a frequent occurrence, and good paying quarries have been worked where 100 tons of rock must be moved to obtain 3½ tons of good slate.

Two kinds of machines for this work are in general use. Both are made with an iron framework, some two and a half feet high, having a horizontal knife edge on the upper side. Working against this knife edge is a curved knife moved by a treadle, the upward movement being given by means of a spring, or, in place of the knife, a cutter revolving on a horizontal axis, much in the manner of a common straw cutter. Either machine has at right angles to the knife edge, on one side, an iron arm projecting toward the workman. In this arm are cut notches for the different sizes of slates.

At many of the quarries a portion of the material is worked up into slabs for billiard tables, tanks, tiles, and mantels. In these cases the block is first split to proper thickness and then cut down to the desired size and shape by means of circular saws. As seen by the writer, a one-fourth inch thick steel saw, some three feet in diameter, with teeth widely expanded at the points and revolving slowly to prevent heating, will cut in a slab four inches thick a scarf three feet long in four minutes. Diamond saws have been used on the harder slates, but are too expensive. Very thick blocks are cut by reciprocating blades of soft iron fed with sand, as used in sawing marble.

The thin slabs used for school slates are squared down to size by means of a thin, ten inch square steel saw, with one long, stout tooth on each of its four corners. Revolving at the rate of 2,000 revolutions per minute, this will clip off the edge of a slate without splintering or fracturing, as cleanly and quickly as a common circular saw clips off the end of a clapboard or shingle. The large slabs for billiard tables, etc., are planed to thickness by machines similar to those used in planing metal, but with a broader cutter, and ground down by hand or by large horizontally revolving iron beds fed with sand and water. School slates are worked down either by hand or machine. In the first method the workman lays the thin slate, cut to proper size, on a flat board in front and inclined steeply toward him, and with a wide drawing knife shaves off all the inequalities, in much the same manner as were made the old-fashioned shaved shingles. By the machine method the slate is forced vertically downward between rapidly upward revolving emery rollers, over which streams of water are constantly playing.

The latter method, besides being the more rapid, produces a surface more uniformly even. School slates, after trimming and scouring, are dyed by being wholly immersed for a period in a tank of dark, nearly black liquid dye. This permeates the slate thoroughly, and produces a deeper, more uniform, and pleasing color than the natural material affords.

The framing of school slates is done largely by boys from twelve to twenty years of age. The four pieces constituting the frame are cut to proper length, grooved and beveled by gauged saws and planers. Boys with piles of these prepared slips before them rapidly apply glue to the tongued and mortised ends; other boys then take the pieces and deftly fit them around the slate, which has been already cut and trimmed to the exact size. They are then passed on to another party, usually a man, who, by means of an ingenious system of clamps worked by foot power, crowds the frame from all four sides at once closely about the slate. In many cases the frame is stiffened by wooden pins, one at each corner, or is hooped by copper wire sunk in a groove previously cut around the outer margin. Finishing touches are put to the woodwork by placing the framed slate between rapidly revolving rollers or horizontally revolving beds covered by sand paper, which scour off all inequalities, and the framing process is practically complete. The felt borders seen on many slates are sewed or glued on by girls. The sewing at some factories is done by machine, the needle or awl punching its own hole through the woodwork at the same time it carries the thread. At others the boring the holes through the frame is a separate process, and the sewing, if such it can be called, is done by hand. The entire process, by aid of machines and a detailed division of labor, has been made extremely rapid.

The following table, taken from F. W. Sperr's account of quarry methods, in the report of the 10th census, shows the division of labor and the number of hands employed in a factory capable of turning out 20,000 framed school slates daily.

OPERATIONS.	Number of Men.	Number of Boys.	Number of Women.
Trimming the slates.			
Marking into rectangles and sawing with small circular saws.	2		
Shaving the surfaces smooth with draw knives	6		
Framing the slates.			
Sawing boards into lengths for frame pieces	1		
Sawing and grooving frame pieces.	1		
Tenoning and mortising frame pieces.	1		
Gluing tenons, mortises and grooves, and sticking together an end and two side pieces		1	
Placing the frames on the slates		1	
Pressing the frames firmly on the slates with a machine press		1	
Trimming the corners of the frames	2		
Planing the frames	1		
Printing rules on the inner edges of the frames			2
Punching holes in the frames			2
Sewing cloth upon the frames with shoe strings			24
Packing and boxing the slates		1	
	14	4	28

A second bed of slate rock, but occupying a lower geological horizon, lies to the southeast of the one above described. Beginning in the southwestern part of Lancaster County, it extends across the Schuylkill into York County, and thence across the State line into Maryland. Quarries have been worked from time to time and at various points in this belt, though never so fully developed as in the beds of Lehigh and Northampton Counties. After Pennsylvania, the slate-producing States, named in the order of their importance, are Vermont, Maine, Maryland, New York, Virginia, New Jersey, Massachusetts, and Georgia. With the exception of a portion of the New York output, which is of a red color, the quarry product displays but little variety in color, varying from deep blue black through purplish, dark gray, and greenish. The dark hues are due mainly to carbonaceous matter and the red to iron oxides.

The essential qualities of a good slate for roofing purposes, other than the faculty of splitting readily into thin sheets, are durability of color and toughness. The dark colors will nearly always fade to some extent on prolonged exposure, and the ribbons almost invariably give off a whitish efflorescence indicative of the presence of an iron sulphide. All such portions must therefore be rejected in the process of trimming. If the slate be too soft, the nail holes will become enlarged and the slate loosened from the roof; if too hard and brittle, it will splinter in the process of trimming and "holing," or will break when trod upon, as is frequently necessary when roofs are being repaired. For school slates a soft slate is required, absolutely free from hard spots and flaws of all kinds.

As slates are rarely used where subjected to great compressive force, but few tests have been made to ascertain their powers of resistance. Prof. Crosby, of the Massachusetts Institute of Technology, has tested the Maine slates, and found them capable of sustaining a pressure of 29,870 lb. per square inch on the bed and 16,750 lb. on edge.

The statistics of the slate-quarrying industry for all the States above mentioned for the census year of 1880 were as follows:

Whole number of quarries	94	
Total capital invested	$3,328,150	
Total output	457,267	squares
Value of output	$1,529,985	
Number of hands employed	3,033	

Average day's wages per hand:

Skilled labor	$1 75
Unskilled labor	1 17

THE BROWN PACA.

SOME weeks ago, one of the readers of *La Nature* sent to the editor a photograph which we reproduce in Fig. 1. It represents a paca, a South American rodent, which was captured a month ago in a sweep net by Mr. Vincent, fisherman of Boulogne-sur-Mer. "How," says Mr. Feau, "did this animal come to be on the Seine? This is something that will probably never be known. The animal is very gentle and lives on good terms with the cats of the house. It eats bread, cakes, snails, and sugar, and drinks coffee, brandy, etc. It jumps upon a table with ease, and has a more active appearance at night than during the day. Its head is continually in motion and it is constantly nosing about. It is a female."

FIG. 1.—PACA TAKEN AT BOULOGNE-SUR-MER.

It is very probable that the animal came from the Garden of Acclimatation, where there is a small colony of its kindred which propagate with regularity every year. In the first fortnight of February of last year this establishment received still another specimen, which came directly from Brazil. Can it be this latter, that, ill received by its congeners, has succeeded in escaping, and reaching the Bois de Boulogne and then the banks of the Seine?

These animals form burrows and are excellent miners. Moreover, they are extremely agile, and get over very high barriers. Which of those two means did the captured paca take to gain its liberty? This remains to be found out.

This is not the first time that it has been observed that the paca can be easily domesticated, even in France. Buffon owned one, which he brought up in liberty in his house, and, in his General and Particular History of Mammals, he gives some interesting details concerning this rodent. Since then, other pacas have quite often been brought alive to Paris, and as they eat all vegetable substances, and even meat, and as they readily endure cold, Cuvier and other naturalists have thought that these animals might be introduced on our farms, where they would prove a valuable acquisition, an account of the delicacy of their flesh; but this idea has not yet been carried out.

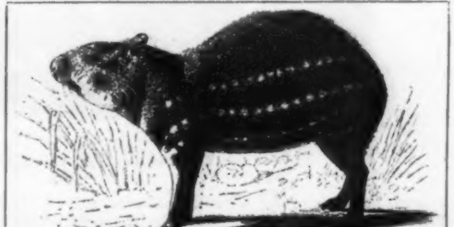


FIG. 2.—THE BROWN PACA.
(*Cœlogenys Paca.*)

As regards its natural history and habits, the following are the data that we possess in regard to the animal.

The paca belongs to the order Rodentia. It has a thick and squat body, a large head, a wide snout, and large eyes, with a round eyeball. Its ears are of medium size, and are rounded and wrinkled. Its mouth is provided with pouches inside, and there are also others externally under the form of a fold in the skin beneath the projection that limits the cheeks under the eye. The teeth are like those of the hare or rabbit. The legs are not very large, and are nearly of the same length as those of the agouty. The fore legs terminate in four-toed feet, and the hind legs in five-toed ones. The inner and outer toes are very small, as if rudimentary. The nails are strong, thick, and conical and adapted for digging. The animal has no tail, this being replaced by a simple tubercle. The coat consists of short, stiff, sparse hairs.

The female has four teats, two pectoral and two inguinal, and gives birth to but one young one, which, says Brehm, she keeps for a long time in her burrow. Naturalists distinguish three species of the paca, which are scarcely differentiated except by the color of their coats. There is the brown or black paca, the tawny paca, and the white paca. Little is known about the latter.

The two first species have long been confounded, and the fact is that the color markings are the same; but, aside from its lighter color, the tawny paca is distinguished from the brown one by its jaws and by rugosities upon its cranium, which are perceptible externally, while the brown paca has a smooth cranium. Aside from these details, they have the same stature, the same habits, and inhabit the same countries; but, nevertheless, it is the brown paca that is best known. This latter (the species captured on the Seine) is 12 inches in height at the shoulders, and more than that at the center of the back, which is prominent. Its length, from the tip of the nose to the rump, is 20 inches. Its coat is brown above and at the sides, where there are four or five lines of white spots, more or less distinct or confused. The throat, breast, belly, and internal surface of the legs are of a dirty white. The whiskers are very long and are black and white.

The brown paca is found in Brazil, Paraguay, Guiana and the Antilles. It inhabits low, damp forests, and, as a general thing, establishes its dwelling near water. It excavates burrows after the manner of the rabbit, but the burrows are not so deep as those of the latter and are near the surface, for their vault gives way under the foot of the passer-by. The mouths of these galleries, which are three in number, are hidden under a mass of leaves and dry branches. On account of the delicacy of its flesh, the paca is eagerly hunted for, and many are destroyed; so in certain countries the animal is becoming rare. It may be taken alive by means of purse nets, as our hares are, but the capturing is a more dangerous operation, as the paca defends itself and tries to bite. Its voice resembles the grunt of a little pig.

The animal often sits upright engaged in washing its whiskers with its fore paws, which it licks every time that it passes them over its snout. Despite its apparent heaviness, it runs and jumps with nimbleness, and dives and swims very well. Its food consists of fruits and roots, and it often ravages sugar cane plantations. Its habits are nocturnal, and it hardly ever leaves its burrow except at night.

Unlike French naturalists, Brehm thinks that the acclimation of the paca in Europe would prove of no advantage; yet he admits that the animal is very fat in February and March, that then its flesh is well-tasted and is much esteemed, and that it is very fine game, which is brought to the market under the name of "royal game." We think that Brehm is not very consistent, and that an animal which has so many good qualities, which is so little particular as to food (since it eats everything), and which is so slightly sensitive to cold, is fit to be propagated.—*La Nature.*

A PLAGUE OF FLIES.

"MAGAS-KAH, mard-i-shikam kai kardan" is a Persian proverb which means that "A small fly will upset a big man's stomach." In a small compass you have in the fly as good an emetic as need be. Why the Persians adopted the above proverb is evident to any one who has visited their cities and villages. In the festering filth which there abounds and increases, the fly finds a happy covert and hunting ground. The fly, however, is not confined to Persia alone, for its gre-

garlousness is proverbial. Those who took part in the Afghan campaign of 1879–80 will have a lively recollection of the swarms of flies that infested the camps of Barrakab, Jellalabad, Pezwan, and Kabul. It was a common thing to see the whole camp of officers and men seized after meals with an attack of nausea, much as if they were on board a troop ship in a storm in the Bay of Biscay. So great was the fly plague during those memorable summers' campaign that it was found impossible to cook food without numbers of those pestiferous insects trailing their poisonous bodies over it and imparting to it an unpleasantly medicinal effect. Toward the end of summer the flies became languid, and, if possible, more loathsome; for they would light on one's face and hands, and hang there until they were literally brushed off. It was found impossible to drink tea or any other liquid without taking it from a bottle; and it was only with the greatest dexterity that one could pass the neck of the uncorked bottle into one's mouth without the flies gaining admission thereto. It would be difficult to express the amount of misery which they occasioned until winter set in and they made off in search of more congenial climates.

But as downright pests the sandflies of the Egyptian deserts take the palm. Fort Tel-el-Kebir, the day after the battle there in 1882, presented an extraordinary collection. It was the scene of a great and perhaps unsurpassed gathering of flies. It may be remarked that the Egyptian troops had neglected to bury their dead; in fact, the Egyptians had to take to their heels quite suddenly, and the British did not trouble to bury the enemy's dead, so that the bodies of the dead Arabs and Egyptians lay about the trenches and fort walls. Long before I got to the trenches I noticed a dark line distinctly visible on the otherwise bright, sandy landscape, and as I got nearer the fort seemed to be covered with a dark pall. I could not account for this phenomenon at first, and at the instant it was suggestive of something supernatural. On nearer approach, however, at about 150 yards distance from the dark mass, I heard distinctly a loud humming noise. As I approached nearer the sound increased in volume until it became a loud roar. It was not until I was close to the black line that I could make out the cause. Then I could see the topmost flies as they hovered and dived above the lower strata. I could trace this black line of flies for a half mile or so on either side of me; and it rose like a thick curtain for some ten yards off the ground. Here is a calculation for some mathematician. A wall of flies one mile long, ten yards high, and forty yards wide; and the flies so thickly massed that they might be said to be riding one on top of the other and brushing each other side by side. This black wall represented the line of dead Egyptians; and, certainly, if they were unburied, they did not want for a pall. How I was to get through this cordon of flies was a doubtful problem. Time was pressing; and a party of Arabs were hanging behind and enjoying some nice ball practice with my pony and me for targets. To go around the flank of this fly wall was out of the question; so I put spurs to my pony and urged him through. The brute refused several times, literally frightened by the hum and noise. At last I managed to get him "head on;" and never shall I forget my passage through those forty yards of flies. They presented such a firm front as we passed through that I could feel a heavy pressure—heavy enough to compel me instinctively to grip the saddle closer with my knees. I had to close mouth and eyes, and trust to chance to get straight through; and it was no easy matter to endure the horrible stench that emanated from the mass. My pony was so terrified that I could not pull him up until we had got some hundred yards beyond the black mass and out in the clear desert air again. I looked behind me now and again as I continued on my journey, and there, in the blazing sun, was the same dark pall—a distinct feature in the desert, and to me a hideous memory of flies. I may further mention that I passed by these same trenches a week after; and the dead bodies were still there—now black, bloated masses, save that in some cases a black stain in the sand, surmounted by a skeleton, told where once there had been human flesh. But the fly hordes had gone; even they were satiated when there was nothing left but the animal juices. From this, too, I conclude that flies, however numerous, play but a small part in the dissolution of dead bodies; putrefaction under a hot sun is so rapid that the air is the great absorbing factor; but that the flies help the process goes without question.

It would appear that the heat in some Oriental countries is a powerful agent in breeeding fly *ova;* and as there is little shade or moisture elsewhere than in the village huts and by the village tanks and wells, the fly world, as a matter of course, make for the shade to escape from the broiling sun and the arid regions around; hence they are found about human habitations, where they can not only get shade, but in the filth of both place and people find all they desire in the way of food. Evidently the fly is nature's great sanitary reformer.

As to the traveling propensity of flies, any one who has traveled much with camps in the East must have noticed with what tenacity the fly hosts stick to the moving camp—baggage, camels, horses, and men being literally covered with them on the road from camp ground to camp ground. Often, when traveling alone from one encampment to another in India, I have noticed the usual *posse* of flies following in my wake, or more often perched on me or my pony. Often have I galloped ahead to shake them off; but to no purpose—they can race for miles at a stretch, and keep up with a horse at a trot. You may shake them off by hard galloping for a time, but they will keep on the scent and overtake you by and by. I used to think at first that I had got rid of my tormenters after a long gallop, and that the flies that turned up when I drew rein were fresh relays; but I found out from observation that the flies that left one camp with me usually followed me to the next. Certainly those flies that leave one camp may be augmented by stragglers on the way, and some may fall out on the journey; but the bulk keep with the traveler throughout the distance. The most interesting experiment I ever tried with flies was to catch a dozen or so and give them a bath in cochineal, thus dyeing them red, and then to look out for the red flies when I got to the camps ahead. In this way I was astonished to find one or two of the number appearing day by day, and at least half a dozen of the twelve I originally dyed traveled with me for over 300 miles.—*St. James's Gazette.*

PARASITES OF THE VEGETABLE KINGDOM.

PARASITIC life is not peculiar to animals, for there are many plants which exist as parasites. Growths of this kind save themselves the work of forming organic combinations from water, the nutritive salts, and the air; they receive them from other living organisms.

The parasites can be divided into three groups, according to their manner of obtaining their sustenance. The first of these includes only microscopic forms (bacteria, etc.), which live chiefly in the internal organs of men and animals; the second includes all of those fungi whose mycelium are capable of penetrating or covering the supporting plant in such a manner as to appropriate their sap. The third class consists of blossoming plants which come from seeds, but take the already prepared nourishment from their supporting plant by means of the filaments which penetrate the body of the latter. We will mention a few of this last class, particularly those which are natives of Europe.

First of all, there is the so-called virgin's bower, the most widespread representative of the genus Cuscuta. This works among hop plants, completely destroying them, attacks the elder and ash, but prefers the dodder. The seed of the *Cuscuta europea* germinates in damp ground or in the rotten bark of old tree trunks. It shows remarkable peculiarities of growth, which we, however, cannot illustrate, but we will call attention to the fact that the thread-like shoots grow very rapidly and try from the first to cling to living plants (blades of grass, leaf stems, etc.), growing around their support in the direction of the hands of a watch. Where the parasite comes close to the other plant, little papillæ are formed close together; see Fig. 1a. With the papillæ the Cuscuta raises itself on its support, and soon a bundle of cells is projected from each papilla (Fig. 1b), which grows into the other plant. These cells or filaments penetrate often to the center of the wood. In the interior of the stem of the hop vine or other supporting plant the cells separate and operate like a sucking apparatus, forming an organic combination with its sustainer. After a certain length of time that part of the stem below the first papilla dies, leaving the Cuscuta no connection with the earth.

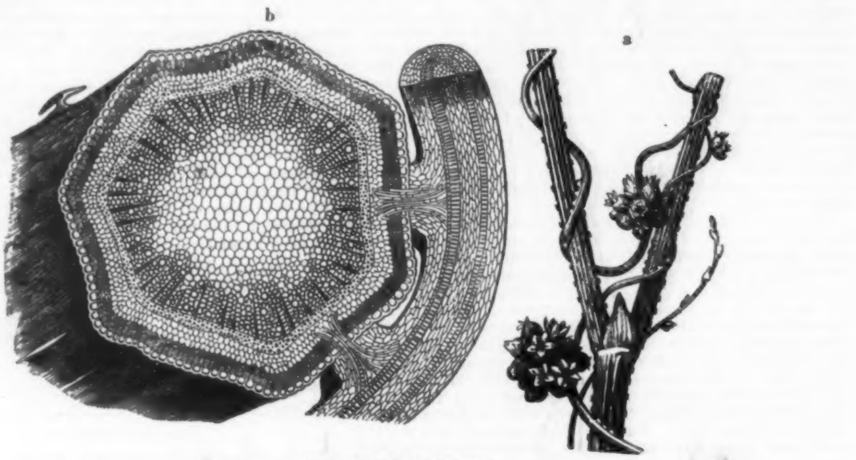


FIG. 1.—VIRGIN'S BOWER.

a. Growing on the stem of a hop vine. *b.* Cross section enlarged 40 times.

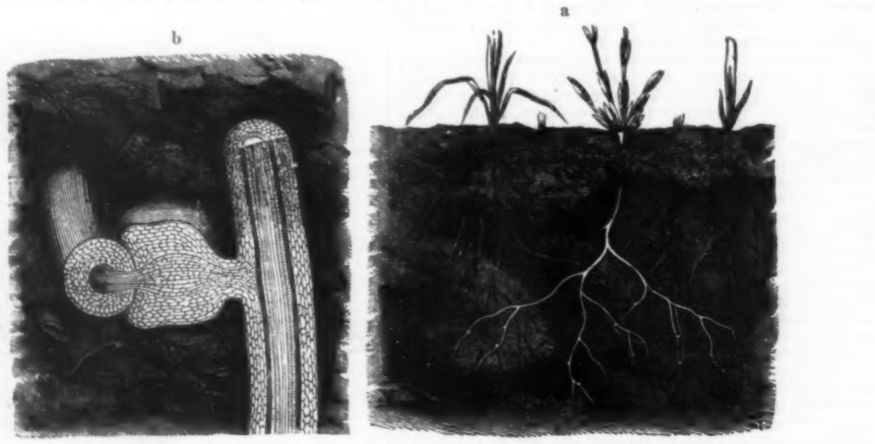


FIG. 2.—THESIUM ALPINUM. (Natural size.)

a. Roots with papillæ. *b.* Cross section of root with papillæ. Enlarged 55 times.

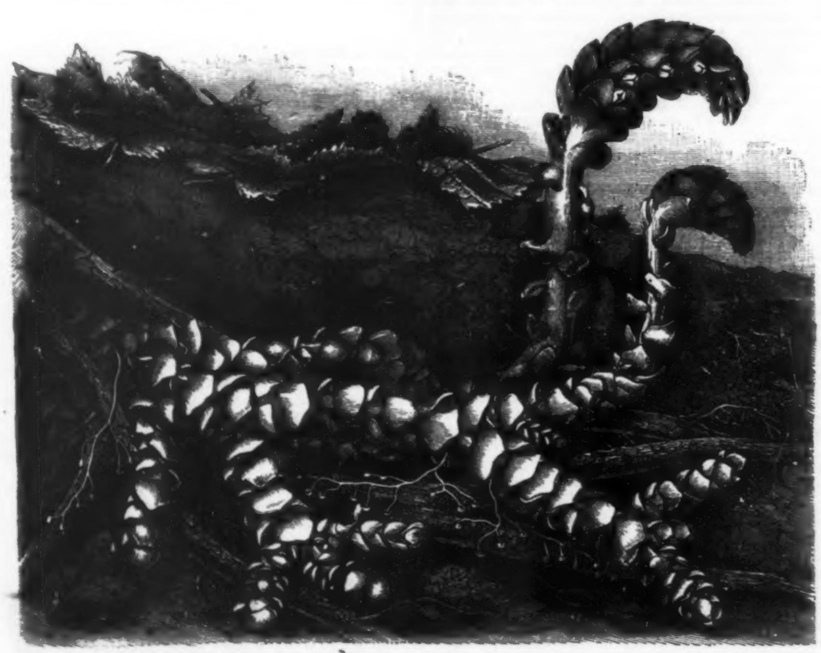


FIG. 3.—LATHRÆA SQUAMARIA, WITH PAPILLÆ AND ROOTS.

Fortunately all European Cuscutæ are annuals. When they attach themselves to perennials they wither after their seeds have ripened. In the tropics perennial species live; for example, *Cuscuta verrucosa*, the papillæ of which operate for years. There are fifty kinds of this plant, which are spread with considerable uniformity over the whole world.

Other flowering parasites attach themselves to the roots of other plants.

Among these is the *Thesium alpinum*, which is shown in Fig. 2a; b represents a cross section of a piece of

root with papillæ. Each button-shaped papilla consists of a core and a bark-like covering, which forms like a cushion around the root of its host, while filaments spring from the core which penetrate to the center of the root attacked. A number of plants of the genus *Rhinanthus* live in this way, viz., eyebright (*Euphrasia*), yellow rattle (*Rhinanthus*), cow wheat (*Melampyrum*), etc., but in all of these plants the filaments, etc., are all smaller and more delicate than in the *Thesium*, and are sometimes difficult to discover.

A well-known parasite is the toothwort (*Lathræa squamaria*), which is illustrated by Fig. 3. This differs from the plants already described in having no green leaves, but in other respects is closely related to the *Rhinanthus* and *Melampyrum*. With the exception of a short time in each year, during which it sends a blossom covered sprout above ground, it exists entirely underground on the roots of leaf-bearing plants. The seed of the toothwort germinates in damp earth; the little roots sink perpendicularly and send out lateral shoots, which, as well as the main root, take a serpen-

FIG. 4.—LANGSDORFFIA HYPOGÆA, FROM CENTRAL AMERICA.

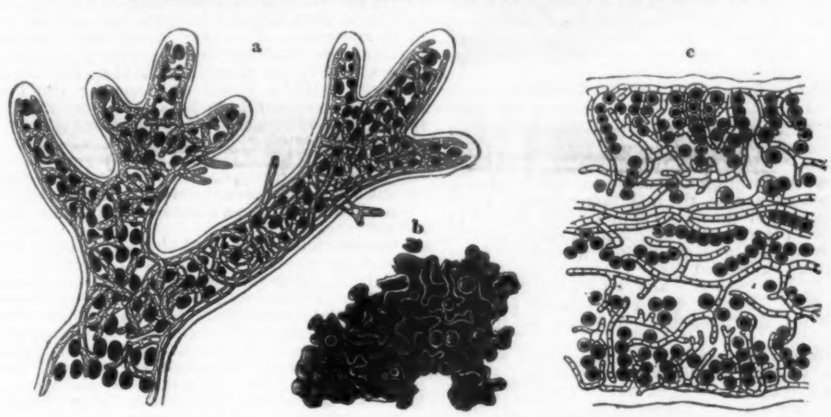


FIG. 5.—WEAVING OF FUNGUS FILAMENTS AROUND ALGÆ CELLS.

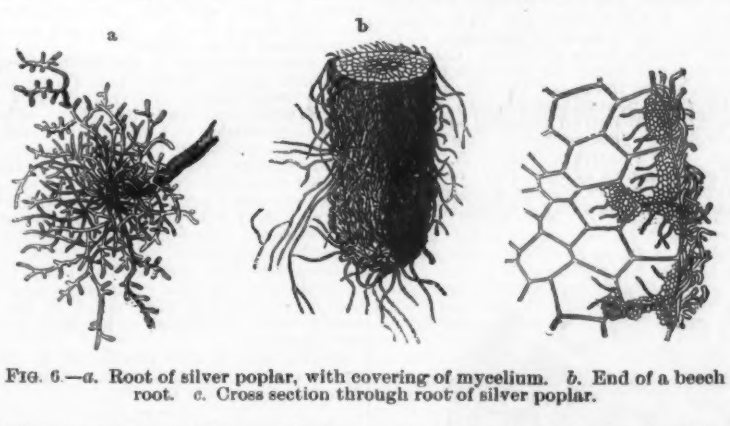


FIG. 6.—*a*. Root of silver poplar, with covering of mycelium. *b*. End of a beech root. *c*. Cross section through root of silver poplar.

tine course. If they come upon the living root of an ash, poplar, or hazel, they attach themselves to it, forming, at the points of contact, papillæ which are at first club-shaped and then disk-shaped. These disks fasten themselves to the attacked root by means of a sticky substance, and then, as in the plants already described, a bundle of filaments is sent out from the core of each papilla which penetrate and draw nourishment from the root of the supporting plant. The ends of the stems grow rapidly and develop leaves which are destitute of chlorophyl and resemble scales. The flower stalks, which rise from the ends of the underground stems, are at first hook-shaped (Fig. 3), but straighten out as the fruit ripens. The cavities in the leaves of the *Lathræa squamaria* are provided with a slimy secretion by means of which insects and infusoria are captured. The *Balanophoraceæ* of Brazil sustain themselves in the same manner as toothwort. In Fig. 4 we show a characteristic representative of this genus, of which there are forty kinds, but none of these is found outside of a belt which extends only a comparatively short distance north and south of the equator. The *Langsdorffia* has a cylindrical stem which, later, bears the blossom stalk; it is nearly a foot long, and has club-like enlargements at the points of contact with the root on which it fastens itself.

The parasites of which we have spoken heretofore take their sustenance from other plants without rendering them any service in return, but there is another class in which the two plants form a single organism, a union from which they derive equal advantages. One plant takes nourishment from the earth and the air and carries it to the other plant, in the green cells of which the raw material is changed into an organic combination by the influence of the sunlight. Few know that lichens are included in this class. Many of these appear, as is well known, like a crust on stones, on the ground, or on old wood. Upon microscopic examination they all show the combination of green algæ cells with fungus filaments free from chlorophyl. In Fig. 5b we illustrate the *Collema pulposum*, full size; c shows a section enlarged 450 times, in which the algæ cells, surrounded by the fungus filaments, can be seen all through the body of the lichen. *Ephebe kerneri* (Fig. 5a), on the other hand, shows these threads much more strongly developed, while the algæ cells are arranged in band-like rows.

Sometimes the filaments of the fungus growth penetrate into the outer cells of the roots as shown in Fig. 6c.

The above is taken from the excellent work by Prof. Anton Kerner, of Innsbruck, called "Plant Life," published by the Bibliographischen Instituts of Leipzig.—*Illustrirte Zeitung.*

THE POISON APPARATUS OF THE MOSQUITO.

By Prof. G. MACLOSKIE.

THE oral armature or proboscis of the mosquito (*Culex*) is described and figured in Dimmock's *Mouth Parts of Some Diptera*, and consists of a labrum, two mandibles, two maxillæ, surrounding a hypopharynx, and all these inclosed in a loose scale-covered sheath, which is the labium. They are nearly three millimeters long, about four times as long as the head; and all except the sheath are smooth, chitinous stylets. The maxillæ bear maxillary palps, scaly, four-jointed, about as long as the head in *Culex*, and three times as long in the allied genus *Anopheles*. I have only to add to Dimmock's description that besides the somewhat coarse serration of the maxillæ (about fifteen teeth near the top of each), Minot S. Morgan, of Princeton, has shown very fine serrations on the upper part of the mandibles (about forty-two minute teeth on each).

The hypopharynx is in the axis of all these mouth parts, being inserted by a basal enlargement close behind the oral aperture, and flattened so as to form the floor of a sucking tube whose sides and roof are formed by the grooved labrum (or labrum epipharynx according to Dimmock). This sucking tube extends back in the head, piercing between the upper and lower brain, and enlarged in the posterior part of the head into a large pumping organ, which forces the imbibed fluid backward into the œsophagus and stomach.

In the last century Reaumur thought he could detect a drop of saliva ejected by the proboscis when stinging; he supposed that this is poisonous, and that its special function is to prevent the coagulation and thus to promote the flow of blood by suction when the insect operates on our skin. We do not believe that he possessed any instrument that could show the poison, but his inference as to the presence of poison and its function is almost certainly correct. It seems to us, however, that the chief food of this insect is not animal blood, but the proteids of plants; and probably the fluid ejected may prevent the coagulation of all proteids, and so promote the process of suction.

It has been very often suspected that the poison duct is contained in the hypopharynx, which has a thickened axis, like a rod, supposed by some observers to be tubular. Dimmock made out the tubular character of the corresponding part of some of the larger non-poisonous Diptera, but he was not able to demonstrate its tubular character in Culex. In addition to his observations that go to prove the existence of poison in its bite, I may add my own observation, that even when failing to draw blood its bite will sometimes swell the part, the subcutaneous tissue being irritated by poisonous matter. He concludes from the careful examination of all the parts that no other channel can conduct this poison; and adds, "This, together with the position occupied by the salivary duct in other Diptera, leads me to believe, without as yet being able to give anatomical proof of it, that the hypopharynx of Culex contains a duct that pours out its poisonous saliva;" and he further states that he was unable to determine the actual presence of the glands.

A year ago I succeeded in making out the duct and also the glands, and published a preliminary note; I was unable, however, at that time, to correct errors or to complete the work. The past summer, however, gave me an opportunity of revising the subject, so that I have acquired some facility in finding and dissecting the parts. I find that it is even easy to see the venomo-salivary duct from the outside, shining through the skin at the base of the head and neck in the undissected specimen. Also, thanks to the supervision of Professor Libbey and the manipulation of Dumas Watkins, of Princeton Histological Laboratory, I have been supplied with a set of excellent sections, which show the relations of the parts. One of these sections is here engraved in part (Fig. 1), exhibiting the insertion of

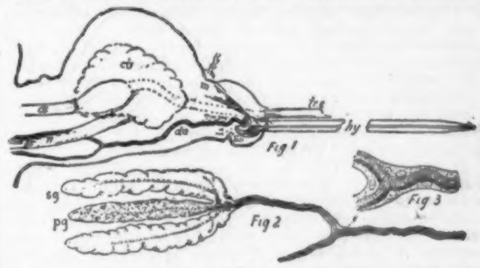


Fig. 1. Median section of head, showing (*ds*) the venomo-salivary duct, with its insertion in (*hy*) the hypopharynx; *cb*, cerebrum; below this is the cerebellum, and the pumping enlargement of (*œ*) the œsophagus; (*lr, e.*), base of labrum epipharynx; (*m*) muscle; (*n*) nerve commissure. Other parts removed.
Fig. 2. The venomo-salivary duct, showing its bifurcation, and the three glands on one of its branches; (*pg*) poison gland; (*sg*) marks the upper of the two salivary glands.
Fig. 3. The bifurcation of the duct, with its nucleated hypodermis.

the duct into the base of the hypopharynx, and its course below the nerve. I have also teased out and stained some of the glands, which have enabled me to show their structure and relations, as in Fig. 2.

The secret was first discovered by an observation of fine droplets of a yellow, oily-looking fluid escaping from the apex of the hypopharynx (Fig. 1). I was then able to trace the course of this fluid down through the axis of the hypopharynx, its being divided in parts into droplets, and so indicating the tubular structure of this organ. On examining the base of the hypopharynx I found it to be enlarged like the mouth of a trumpet, and provided with a sac-like reservoir, into which the end of a fine duct was inserted. Working backward, I saw the duct to be of the usual character of salivary ducts in the Diptera, but much finer than usual, being less than eight microms in diameter, against thirty-seven microms in the house fly.* It is not readily identified by a low microscopic power, and this may explain why it has not been previously detected. It has the usual chitinous lining, surrounded by the nucleated hypodermis which secretes it, transversely striated as in tracheæ (Fig. 3); but it is distinguished from the tracheæ by the comparative smallness and constancy of its diameter, and by the absence of ramifications. It runs back in the lower part of the head, beneath the nervous commissure (*n* in Fig. 1), for two fifths of a millimeter. In the throat it bifurcates, its two branches being each as long as the undivided segment, and running on the right and left of the nerve cord into the prothorax, where they terminate in glands of characteristic structure.

The glands are in two sets, one on each side in the antero-inferior region of the prothorax. Each set consists of three glands, two of which are of the usual aspect of salivary glands, resembling in structure, but not proportionately as long as, the single salivary gland on each side in the prothorax of the house fly.

* A microm is one thousandth part of a millimeter, or one twenty-five-thousandth of an inch.

The third gland, that occupying the center of each set, is different, being evenly granular, and staining more deeply than the others; its function being, without doubt, the secretion of the poison. Each gland is about one third of a millimeter long, and one twenty-fifth of a millimeter broad; the three are arranged like the leaves of a trefoil; and each is traversed throughout by a fine ductule, the three ductules uniting at the base to form a common duct, which is like a pedicel of the trefoil and is one of the branches of the bifurcated venomo-salivary duct. The ductules of the lateral glands of each set receive a minute branchlet near the base. Thus there are six glands, three on each side, two of them poisonous and four salivary, their secretion diluting the poison. The two efferent ducts, one from each set of glands, carry forward and commingle the venomo-salivary products in the main duct; and the stream is then carried by the main duct to the reservoir at the base of the hypopharynx. There is no other exit for the contained fluid. I see muscles apparently inserted on the framework of this reservoir (Fig. 1, *m*); but Dimmock seems to think that the hypopharynx is not furnished with muscles. However this may be, the pressure exerted on it by the surrounding parts, when the mosquito inserts its piercing apparatus into the flesh or through the epidermis of a plant, is sufficient to propel the poison through the tubular axis of the hypopharynx into the wound. The reservoir must be furnished with a valve to prevent the reflux of the secretion. The distal orifice of the hypopharynx is not exactly terminal, but sub-apical, as is usually the case with fangs; the very tip is somewhat flattened, and sharp, so as to enter easily into and to enlarge the wound made by the adjoining organs.

Careful observations are needed as to the behavior of mosquitoes on plants; as to the condition of the hypopharynx and the glands in the males and in the larvæ. The observations here noted were made on the adult females of Culex (*C. tæniorhynchus* Desv.), and on a species of the allied genus *Anopheles*, which is characterized by its long maxillary palps.

Princeton College, Sept. 18, 1888.

—*American Naturalist.*

DAISY TREES.

(OLEARIAS.)

To make matters plain, we must begin by following the lead of botanists who have merged the genus Eurybia into Olearia, so that all those plants which have been known by the former name must now be called Olearias. The name Eurybia is entirely obsolete. This gives us a genus of over eighty species, all of them natives of New Zealand and Australia. Most of the kinds in cultivation here are natives of the former country. But among the Australian species there are many beautiful shrubs which would pay for their introduction. Indeed, O. insignis is exceptional among the New Zealand kinds, but resembles some found in Australia. In the latter country there are species with large flowers in which the ray florets are blue. The genus is very closely related to Aster, which is so extensive in the northern hemisphere, especially in America.

The species already in cultivation are really useful and handsome shrubs, easily cultivated, evergreen, very free-flowering, and of good habit. The only drawback is their not proving hardy, except in warm localities. Still, there are a great many gardens where they will grow and thrive perfectly, and there is also the chance that in time most of the kinds will get acclimated sufficiently to bear an ordinary English winter. Besides, some of them, as, for instance, O. insignis, are good greenhouse plants.

O. insignis.—This is the most remarkable species yet introduced. The Kew plant from which the plate was made was grown in a cool greenhouse along with Cape heaths. It appears to be a very slow grower when cultivated in a pot; probably it would grow more rapidly if planted out of doors in a warm, sheltered situation. The plant is about a foot high, branched, the branches as thick as the little finger; the leaves are from 3 inches to 5 inches long, 2 inches broad, rounded at the ends, very thick and hard, shining green on the upper surface. With this exception the whole plant is covered with a thick, felt-like coating of pale brownish tomentum. The flowers are on erect peduncles, which are as thick as a goose quill and from 6 inches to 9 inches long. The flower heads are a little over 2 inches across; the involucres covered with stiff needle-pointed scales; the ray florets numerous, white, and the disk broad, compact, and yellow. The flowers remain fresh on the plant for about six weeks. In my opinion this plant is one of the most interesting and prettiest of the composites which are found in Australia and New Zealand. The Kew plant was shown in flower at one of the meetings of the Royal Horticultural Society in the summer of last year. It failed to ripen seeds at Kew. It is a native of Middle Island, in New Zealand, where it is said to grow on the driest rocks

O. argophylla is the muskwood of Tasmania and New South Wales. The whole plant smells very strongly of musk when bruised, a single leaf rubbed in the hand emitting a very powerful and agreeable odor. The wood is useful in cabinet making. Large plants of this species are grown in the greenhouse at Kew, where it forms a shrub covered with oblong, toothed leaves, which are clothed with silky hairs. The flowers are small and of no account, but the plant is worth growing for its fragrance. It is of the easiest possible culture, requiring greenhouse treatment.

O. dentata is cultivated in the Scilly Isles and other favorable localities, where it forms a large bush covered with rusty brown tomentum, except on the upper surface of the leaves, which are about two inches long,

OLEARIA (EURYBIA) RAMULOSA.

ovate, and toothed. The flowers are over one inch across and numerous, in terminal racemes; the ray florets number about twenty, each half an inch long, curved upward, forming a saucer-like head; they are white, tinted with rose, the disk being bright yellow. This is a beautiful flowering shurb which would probably thrive in the south of England in sheltered situations. It grew well at Kew against a wall for several years, but was destroyed by a very severe winter. It is a native of New South Wales, where the flowers are sometimes blue. For the plant introduced from New Zealand under the name of O. dentata, see under O. macrodonta.

O. Gunniana is quite hardy in the south of England. At Coombe Wood it thrives without any protection on a slope and planted in light sandy loam, producing every summer a mass of beautiful blossoms. Against a sunny wall it ought to do in almost any part of England. It forms a bush, with small, toothed, green leaves, the under surface and other parts of the plant covered with white, felt-like tomentum. The flowers (as shown in the illustration) are very abundant, clothing the branches with a mass of white daisy-like blooms, which are borne singly on the ends of hundreds of tiny branches on the upper part of the large branches, and they are one inch across, with about a dozen ray florets, which are half an inch long and white, the disk being yellow. This species is also a good greenhouse plant. It is a native of Tasmania.

O. Haasti.—Whether grown as a pot plant or against a wall or in the open border, or even as a specimen on lawns, this shrub almost invariably gives satisfaction. It is hardy in most parts of England, growing to a large size in the more favored localities. It has been recommended as a suitable plant for sea-side gardens by several who have tried and proved it. If planted in large groups, it has a good effect when covered with its thousands of aster-like flowers, and even out of bloom it is attractive. In New Zealand, where it is found at altitudes of about 4,000 feet, it grows into a small shrubby tree. Here, however, it forms a compact bush, not unlike a box plant. The leaves are oval, three-quarters of an inch long, leathery, shining green above, white beneath, where they are covered with felt-like hairs, as also are the stems. The flowers are very numerous, in terminal corymbs, the ray florets quarter of an inch long, white, the disk yellow. The plants usually bloom in August and remain in perfection several weeks. Messrs. Veitch, of Exeter, were the first to introduce this species, which flowered with them in 1858.

O. ilicifolia is very similar to O. macrodonta, differing in being less thickly covered with down, sometimes almost glabrous, and the leaves longer and narrower. The flower-heads are exactly the same in both species. A plant of the former kind is growing against a wall at Kew, where it flowers in June. It is a native of New Zealand.

O. macrodonta.—This was introduced from New Zealand about three years ago by the Messrs. Veitch, of Chelsea. It is the O. dentata of the New Zealand flora, there being another dentata, the true one, native of Australia, and described above. Mr. Gumbleton, of Cork, who grows these plants successfully, describes O. macrodonta as being perfectly hardy with him, and a most profuse blooming and exceedingly ornamental shrub. Others have described it as being "of doubtful hardiness and not a first-rate shrub." But, as Mr. Gumbleton generally underrates rather than overrates plants when describing them, we may accept his opinion of this species as reliable. I saw it in flower on a sunny border last year at Kew, the plant being about two feet high, with large, silver-green, holly-like foliage and dense heads of whitish flowers. When fully grown, it attains a height of twenty feet, the stem two and a half feet in diameter at the base, the branches stout and forming with the leaves a round, somewhat flattened top, which is hidden by the dense heads of white flowers developed in the month of August. The foliage smells agreeably of musk.

O. myrsinoides was cultivated in Mr. Jackman's nursery, at Woking, and is described as being as handsome and desirable a shrub as O. Haasti. It is a low bush, the short dentate leaves, as well as the branches, being covered with silky down underneath. The flowers are small, in panicles on the upper portions of the branches. It is a native of Tasmania and New South Wales. Here it is said to be as hardy as O. Haasti.

O. nitida.—Mr. Gumbleton grows this at Cork, where it is hardy, neat, and compact in habit, and flowers freely. It forms a large bush, clothed with ovate, leathery leaves about 2 inches long, the branches and under surface of the leaves covered with a thick silvery down. The flowers are in crowded heads or corymbs, very small, but so numerous as to make a good display. They are white with a yellowish disk. This species is a native of New Zealand, at 4,000 feet altitude.

O. ramulosa.—This (see illustration) is a handsome little shrub which has been in cultivation about twenty years under the name of Eurybia ramulosa. It is covered with a rough pubescence; the leaves are crowded, very small, clustered, and woolly on the under side. The flowers are very numerous on long, curving branches, forming elegant sprays of pretty, starry blossoms; each one is small, but they are so abundant and prettily arranged, that the effect of a well grown plant when in flower in September or October is charming. The species is a native of Tasmania, New South Wales, etc.

O. stellulata was one of the first species introduced into England. It was cultivated by Knight at Chelsea and by Loddiges at Hackney at the beginning of this century. It has lately been spoken very highly of by Mr. Hartland and others in Ireland, where these plants appear to find a congenial home. It grows to a height of about 5 feet; the leaves are lance-shaped, toothed, varying in length from half an inch to 2 inches, the upper surface green, the rest of the plant covered with a rusty tomentum. Flowers in leafy panicles, which are long and very graceful in form. Each flower is small, daisy-like, pure white, with about a dozen ray florets. When grown against a wall, this species flowers very freely in June and July. It is a native of Tasmania and New South Wales. There are several varieties of it described by botanists.

O. Traversi.—This is the bastard sandal wood of Chatham Island, where it is the most valuable of the native timber trees. It forms a tree 35 feet high, with a stout trunk and many branches. It flowered a year or two ago outside at Cork and at Stranraer. It has lance-shaped opposite leaves two inches long, the upper surface smooth green, all the rest of the plant being covered with silky down. The flowers are numerous in axillary and terminal panicles, which are produced freely all over the plant. Each flower is small and creamy white. Except in favored localities this species is hardly likely to thrive out of doors. It is of interest as being one of the few members of the very large order Compositæ which form good-sized trees.

O. corymbosa has been noted in *The Garden* as a hardy species cultivated in England, but I cannot ascertain where.

O. gummosa is also mentioned in *The Garden* as a pretty species, which thrives in the neighborhood of Newry.—*W., in The Garden.*

OLEARIA (EURYBIA) GUNNIANA.

ON ORGANIC MATTER IN THE ATMOSPHERE.*

By Miss MARION TALBOT, of Boston.

EXAMINATIONS of the air may be microscopical, showing the solid particles of organic and inorganic composition; biological, proving the presence of micro-organisms or germs; or chemical, indicating the quantities of impurities, both gaseous and solid, present in the air. Of the impurities which claim the attention of the sanitarian, carbonic acid and organic matter stand out pre-eminently. Carbonic acid is not merely noxious in itself, if present in large quantities, but its amount in air contaminated by respiration is ordinarily accepted as the measure of the accompanying organic impurities. Organic matter is acknowledged by all sanitarians to be the most harmful of the injurious components, because even if it does not contain the specific germs of disease, it is, if in excess, the pabulum on which animal poisons feed, among which they increase and through the medium of which they spread. The determination of the amount and character of organic matter in air is therefore an important matter.

* From a paper recently read before the New England Meteorological Society, reported in the *Amer. Meteor. Journal.*

One of the earliest methods employed was based upon the decolorization of permanganate of potash by organic matter. The methods principally in use at present depend on a process by which nitrogenous compounds are decomposed and their amount estimated in terms of ammonia. The modifications have consisted in the use of different absorbers, by means of which the organic matter was collected before distillation in alkaline permanganate.

Experiments have proved that every process of transference may introduce an error, and the sum of these errors may be so large proportionately as to vitiate seriously the result. In the most delicate tests, in spite of the many precautions taken, ammonia was found in the distillate. An experiment showed that a few drops of water trickling over the tip of a finger gave as much free ammonia as several feet of air would give of total ammonia, indicating that inadvertent or incautious handling might prove a serious source of error. A method was accordingly devised by which the air to be examined was treated directly with boiling alkaline permanganate without the intervention of an absorbent. The air was made to bubble slowly through the boiling permanganate by means of a platinum tube. During the passage of the air the Liebig's condenser was inverted and the tube thereby sealed with condensed steam, which served to catch and return to the permanganate all organic matter which might have escaped decomposition at first.

Various kinds of dust were distilled, in order to ascertain the amount of ammonia they contained. It was found that this amount decreased with the lapse of time, showing that oxidation had been going on and converting the dust into innocuous substances during the time when it was exempt from fresh accessions to its amount.

Air containing dust of known weight and composition was examined by the writer's method, the accuracy of which was thus definitely determined.

The figures obtained by the writer were somewhat smaller than those of previous investigators. As the positive errors of all the methods known seem to outweigh those on the negative side, at the present time it is impossible to estimate with certainty the actual amount of organic matter present in the air. All results show that it is so small in ordinary air as to be immeasurable with positive accuracy by chemical means, unless a larger amount of air is tested than is usually practicable, or the air is essentially foul. The positive effects of vitiated air are, however, too well known to be ignored. The products of decomposing animal matter may not of themselves produce disease, but they lower the vital processes and lay the system open to attack from other and more active agents. Among the most active are micro-organisms. They do not come from the breath, but are filtered off by respiration. Neither do they come in any large number from the clothes or skin of persons present in a room. Experiments show that the cleanliness of a house has a good deal to do with the number found in the air.

The presence of an active toxic agent in expired air has been proved by Dr. Brown-Sequard. From the condensed watery vapor of expired air, estimated to be, for an adult, ten ounces in twenty-four hours, there has been obtained a poisonous liquid, which, when injected under the skin of a rabbit, produced almost immediate death. The effect thus produced was due to a chemical organic poison, and not to microbes. This pulmonary liquid has been boiled, and still produced the same effect, and it is now almost certain that this organic volatile poison is an alkaloid. The final deductions are that the lungs produce a very energetic poison which is exhaled with the expired air, and it is extremely probable, if not positively certain, that it is this toxic agent which makes confined air dangerous.

[Continued from SUPPLEMENT, No. 680, page 10861.]

YEAST: ITS MORPHOLOGY AND CULTURE.*

By A. GORDON SALAMON, A.R.S.M., F.I.C., F.C.S.

LECTURE II.

WE have seen that the property of inciting alcoholic fermentation, in saccharine fluids, is by no means confined to what is popularly comprehended under the name of yeast. It is shared—in a minor degree, it is true—by many fungi differing essentially from yeast in morphological structure and manner of reproduction; and it is anticipated that subsequent investigation will lead to the discovery that the power of manifesting the phenomenon is far more widely distributed than is even at present thought to be the case. It is therefore obvious that any definition seeking to limit this power to yeast would be seriously inaccurate and misleading. Yet such was the opinion almost universally held until within about the last sixteen years, when Bail and Reess discovered and investigated the conditions under which *Mucor racemosus* could become an alcohol-producing ferment. Pasteur showed that some species of *aspergillus*, and what he described as *torula*, were possessed of similar properties, and Brefeld finally set any doubts upon the point at rest by proving that the statement held true for all the mucorini.

Then it was thought possible to restrict the interpretation of the term alcoholic ferment, as applied to fungi, by referring the phenomenon of alcohol production to those fungi which effect their reproduction by sprouting. But this, again, was impracticable, because it was speedily proved that such mode of reproduction is not confined to any specific group of fungi, but is evidenced by many heterogeneous forms. Moreover, it was shown that several of the sprouting fungi cannot provoke alcoholic fermentation at all, whereas indications were not wanting of the capacity of certain hyphal fungi to do so.

The researches which have been conducted upon the chemical composition of the yeast cell have yielded no better result, for although they have shed some light upon the true constitution of a yeast food, and may subsequently assist in determining information respecting the internal structure of the cell, it must be admitted that the information which has been gleaned in this subject is more general than special, and applies more particularly to the chemical constitution of fungi as opposed to other cryptogamia.

It is necessary, in view of these facts, to attach some meaning and some limit to the term "yeast" before its systematic study can be entered upon. Fortunately there is a means at hand wherewith to do this which is of practical as well as theoretical value, because it allows of the inclusion of organisms which are available to the brewer, and rejects the majority of those which are either known or are suspected to be productive of harm. It is based upon observations connected with the mode of propagation of yeast.

It has already been indicated that the propagation of yeast can be effected in two ways—by sprouting or budding, and by the production of spores within the mother cell. The former process is normal to the life of vigorous and healthy yeast; the latter can only be effected under conditions which are decidedly abnormal both to the practices of brewing and distilling. Normal propagation by sprouting takes place in a suitable saprophytic food, such as brewers' wort, though it is even then, to a very great extent, dependent in amount upon other conditions in which the supply or absence of air plays a very prominent part. The discovery of yeast propagation by sprouting dates a long way back. There are some obscure indications of its having been noted by Leuwenhoeck in the year 1680. Doubts are legitimately entertained as to whether the credit of this discovery should be given to this investigator, although it is certain that he was the first to examine yeast under a microscope, which instrument had, indeed, just been invented about that time. He describes the general morphology and contour of the cells, and his observations, although recorded, were relegated for close upon a hundred and fifty years to the lumber room of the theorist. In the year 1825 the work of Leuwenhoeck was independently confirmed by two microscopists, Caignard de Latour in France and Schwann in Germany. The sprouting was then observed and described with tolerable accuracy. Moreover, the superiority of instruments over those used by Leuwenhoeck allowed of the discrimination of the older cells from the younger by reference to the more granular contents and harder outlines of the former. But Caignard de Latour did more than this. He was aware of the discovery of Black, about the year 1750, that the production of alcohol during fermentation of wort is accompanied by the evolution of carbonic acid gas and the disappearance or decomposition of the original constituents of the wort, and he made the very pertinent suggestion, "That if yeast could thus ferment sugar, it must surely be by some influence due to its vegetation and its life."

Had his view been accepted, the theories which succeeded it could never have wrought the mischief nor have given rise to the controversy which followed. There is, however, this consolation, that but for the doubt with which the announcement of the propagation by sprouting, and the enunciation of his theory, were received, the experiments of Pasteur, by which the truth of both were indisputably substantiated, would possibly never have seen the light. When we reflect that Pasteur's work upon yeast has constituted the corner stone of modern microscopy, has expanded the philosophical conceptions attaching to a nearer acquaintance with the systematization of nature, and has developed a new school of investigation which has already conferred incalculable benefit upon suffering humanity, we have, in truth, but little reason to regret the result.

Caignard de Latour's views were disbelieved in for two reasons; Ehrenberg, a famous German microscopist, had shown, what is doubtless correct enough, that many mineral and organic substances could, in depositing in a liquid under certain conditions, assume the typical globular form which had been ascribed to yeast without being imbued with life and vegetative functions; and the notion that the life and vegetation of yeast were directly connected with the decomposition of sugar during fermentation was diametrically opposed to the plausible and, indeed, fascinating theory of the illustrious Liebig. Of this theory it will suffice for the present to state that it negatived the possibility of sugar being decomposed, during fermentation, into alcohol and carbonic acid, as a necessary condition to the life and reproduction of yeast in wort. It further negatived the possibility of this decomposition being in any way connected with the sprouting of yeast which Caignard de Latour and Schwann had observed. In place of this theory it substituted one which insisted that instead of yeast growing and vegetating when saccharine fluids were fermenting, it was itself undergoing putrefaction, and that it in this way involved the decomposition of sugar.

This may appear but a trifling theory to refute when we consider it by the light of present knowledge, but in truth it required twenty-two years of the devoted study of a master mind like Pasteur's before the matter was finally set at rest. The clinching proof may be regarded as that wherein he sowed an infinitesimal quantity of yeast in an artificially prepared solution containing sugar and mineral matter, and produced therefrom a large crop of yeast, the growth of which was shown to take place at the expense of the contained sugar. The difficulties by which his task was surrounded arose chiefly from the possibility of errors creeping in from outside sources. These he succeeded in eliminating, and proved beyond cavil the important fact of the propagation of yeast by sprouting. The rapidity of its growth by this means was fairly astonishing when suitable conditions were secured. Thus, in one experiment, he observed the behavior of two isolated cells in wort. He watched them continuously under the microscope for two hours, and found that the cells had, in that time, produced six daughter cells by sprouting. From this he made the computation that 16,000,000 cells would have been produced from one cell in twenty-four hours. He further defined the conditions under which this quantity could be vastly increased. For instance, whereas in ordinary circumstances one gramme of yeast was formed at the expense of 100 grammes of sugar, he showed the possibility of producing 25 grammes of yeast at the expense of the same amount of carbohydrate. This observation was of much value to the grower of baker's yeast, and it should be the subject of more specialized study than it has yet received.

The researches by which he proved the absolute importance of clean plant and pure material in the brewhouse and in the distillery will be sufficiently familiar to you all. He was the first to draw attention to the harm which could be caused by the presence of fortuitous bacteria, which he classed together under the name of "*Ferments de maladie*," and he described numerous specific forms, such as the lactic, the butyric, and the acetic ferment. The value of his advice being promptly recognized in this country, the microscope in due course found its way into every well regulated brewing room, and there are few brewers nowadays who would not acknowledge the debt that is due to Pasteur, if this alone had constituted his contribution to the industry.

But although he worked upon yeast with such unflagging patience, he specialized in one direction, and merely indicated broad generalities in others. His task was to crystallize the truth from the many contradictions which enveloped the theory of fermentation; and it demanded all his time and experiments to succeed in this endeavor. He dispelled any doubt which may have existed as to the fact that yeast was a plant. His experiments proved it to be a fungus, but they did not show to what class of fungi it properly belonged. He indicated that it must belong to some specific group in which there were various species, but the group was not located, and its relations to other fungi were barely discussed. His statements were calculated to induce the belief in the mind of a practical brewer that pure yeast meant yeast free from false ferments; and if this freedom were secured, the production of bad beer through any influence created by yeast was out of the question. This view has been proved to be erroneous. It has been shown to be so by a more detailed study of the botany of yeast, and by an accurate examination of the various species into which it has been proved that yeast, which was formerly considered pure, may now be resolved.

It was not necessary for Pasteur to investigate the more technical questions affecting the botany of yeast, because it would not materially have advanced the problem that he set himself to solve. He proved to the satisfaction of his most bitter opponents the truth of his main contentions, and it was the significance of this very proof which tempted him into a fresh field of work, and caused him to leave to others the completion of the task which he had commenced. Fortunately, it has been taken in hand by able investigators, and has yielded results of greater value than could probably have been anticipated.

Reess, a pupil of the eminent fungologist De Bary, had observed, about the time that Pasteur's experiments on yeast were beginning to attract attention, that the form and mode of reproduction of many fungi was in many cases modified by their conditions of nutriment and existence. He found that certain of the mucorini, which in normal circumstances would develop mycelial growth, could, by variation in the mode of life, be caused to fructify, and diminish their tendency toward the formation of mycelia.

He was impressed with the conviction, previously entertained by Pasteur, and also by Bechamp, that yeast was a comprehensive form embodying a variety of species. If he could absolutely prove the existence of these species, determine their constancy and their reproduction in their pure state, or if he could in any way induce the formation of mucorini from yeast, then he would be enabled to test the value of the pleomorphic theory, promulgated in its most intense form by Hallier, and supported by such authorities as Karsten, Hoffmann, Bail, Mulder, Wagner, and Meyen. It occurred to him that he would be materially assisted in this endeavor if he could so alter the life conditions of yeast as to cause it to fructify, or, at any rate, to vary its method of reproduction. He was strengthened in his conviction by the assertion of De Seynes, in 1868, that the widely distributed fungus *Saccharomyces mycoderma* could form spores in asci—an ascus being, as previously stated, a large mother cell within which spores are developed.

Curiously enough, this observation of De Seynes has been since proved to be entirely wrong, for it has been indisputably proved that *Saccharomyces mycoderma* cannot, as he stated, form ascospores; and the inaccuracy of the observation can only be attributed to the fact that he worked with impure, and therefore unreliable, cultures. When Reess commenced his investigations, he expected to obtain definite information in one of three ways. It would not be possible to effect any change in the mode of reproduction of yeast; it might be that a change, analogous to an alternation of generations, would be produced, which would substantiate the theory of pleomorphism, and elucidate its intricacies; or it might be possible by the discovery of a new method of fructification, and by its aid, to limit and define the number of true yeast species. It was the last of these possibilities which was confirmed by experiment.

The material selected as a substratum for the cultures was a porous vegetable root, as free as possible from sugar, containing much moisture, and capable of freely absorbing more. Slices of well cleansed potatoes, carrots, and so forth were found to answer well. A thin layer of moistened yeast was spread upon such a slice and left to itself in a moist atmosphere. In these circumstances reproduction by sprouting takes place but slowly. The daughter cells are characterized by an absence of vacuoles, or have at most only one. They seem to have no tendency to form chains, and it is rarely that more than two are seen together. Yet the reproduction of the yeast by sprouting is appreciable; and if the limits of the original patch of yeast are marked, an outward extension in the course of a day or two will be noticed. After the fourth day, according to Reess, this extension ceases and the character of the yeast undergoes a complete change. An examination of the yeast discloses some cells which appear to be almost entirely free from internal protoplasm. They soon die and collapse. On the other hand, there are many young cells with many vacuoles, and with the internal contents of the cell in a very granular condition.

These young cells show but slight indications of sprouting. It is to them that attention must now be directed. In the course of about twenty-four hours their granulous contents exhibit a tendency toward concentration, and the vacuoles completely disappear. The granules range themselves in the center of the cell, and constitute separate small islands in its fluid. These are generally from two to four in number, and they are each quickly surrounded by a thin continuous membrane, which completely envelops each granular nucleus. This is the commencement of the new cell formation. The membrane soon becomes thicker, and the differentiation of each new cell more complete, while the only means of identifying the mother cell is by reference to the original cellulose wall, which still

* Lectures before the Society of Arts, London, 1888. From the *Journal* of the Society.

envelops the whole. The diameter of the mother cell has meanwhile increased by about half. If now these cells, that is the mother cells containing the newly formed cells within them, are introduced into a nutritive wort adapted to alcoholic fermentation, the contained daughter cells sprout, extruding themselves through the membrane of the mother cell, and in due course give rise to new cells by sprouting, which are similar to those with which the experiment of altering the conditions of their life was originally performed. The only variation that is noticeable is that the propagation by sprouting is in such a case somewhat slower than in ordinary circumstances. The cycle of changes is therefore completed, and the constancy of the yeast type under the altered conditions of reproduction is fully established.

Fungologists had little difficulty in recognizing this mode of propagation as that of spore reproduction in an ascus, the mother cell developing the spores constituting the ascus; and the observations perfectly correspond to those known to occur in other ascomycetes, in which the asci are small. Indeed, the relationship between this phenomenon and that exhibited by the parasitic group *Exoascus* is so marked as to lead Reess and De Bary to express the belief that yeast which can thus form ascospores is phylogenetically connected with it, and through it with the more highly developed ascomycetes, among which, as previously stated, are included the various well known species of edible mushrooms. It may be, according to the view expressed by De Bary, that the true yeasts represent the simplest form of ascomycetes from which all the others have been developed; or the alternative view is open, that yeasts are greatly reduced ascomycetes, with extensively interrupted homology, which is only restored with the appearance of the asci. In any case, the relationship of yeast to the ascomycetes was fully established by the ingenious investigation of Reess, and its connection with the mucorini and other groups, as alleged by the pleomorphists, was once and forever disproved.

It was shown that the ascospores of yeast when dried, in common with the spores of other fungi, retain for a long time their power of growing.

Reess published the results of his observations in the year 1870, and it was natural that they should have awakened widespread interest. His experiments were repeated by Engel, who added to the extraordinary nature of the discovery by showing, in 1872, that moistened plaster of Paris could with advantage be substituted for the slices of roots with which Reess had worked. Brefeld further showed that ascospores could be formed in a moist microscopic object chamber.

That this spore formation is abnormal to yeast was proved by Reess, who failed to find it in the many samples, which he examined, which were fit for use either in brewing or distilling, but he found that in brewery specimens which were stale and absolutely useless for alcohol production, he could often determine the presence of ascospores.

This discovery is practically the sum and substance of Reess' contributions; he made many other statements, and he described several new species, which he classed as yeasts. He adopted the name saccharomyces previously proposed by Meyen, and employed by Pasteur as a generic term to distinguish the group. Among those which he described should be mentioned *S. pastorianus*, *S. apiculatus*, *S. exiguus*, *S. conglomeratus*, *S. albicans*, and *S. ellipsoideus*, and he reserved the name *S. cerevisiæ* for the true commercial yeasts.

The accompanying illustrations show the form in which the majority of these ferments normally occur when cultivated in saccharine solutions:

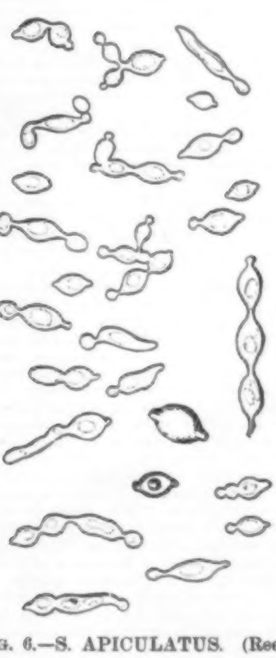


FIG. 6.—S. APICULATUS. (Reess.)

It should, however, be stated in connection with the investigations of Reess that his descriptions were, in many instances, inaccurate, for the very sufficient reason that his experiments were not performed upon pure cultures. Indeed, at the time when his researches were published, the so-called pure cultures had fallen into discredit, and were regarded with disdain by some of the greatest authorities upon the subject. Indeed, Reess laid special stress upon the fact that his cultures were not pure. It remained for others to prove that, had they been so, he would not have fallen into the error of asserting that many of his species formed ascospores, when, in reality, they do not; that high and low fermentation yeasts were one and the same, subjected to different conditions of life, when in reality they are distinct and true varieties. Nevertheless, it is scarcely fair to Reess to consider his work with reference to its faults; because they are apt to obscure its great and conspicuous merits. If it did nothing else but prove the possibility of yeast developing ascospores, it would still remain as an invaluable contribution to the science of the subject.

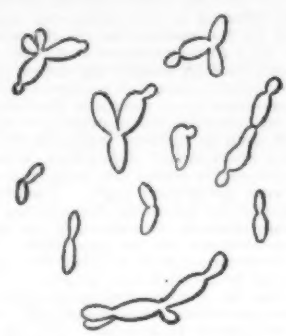


FIG. 7.—S. EXIGUUS. (Reess.)

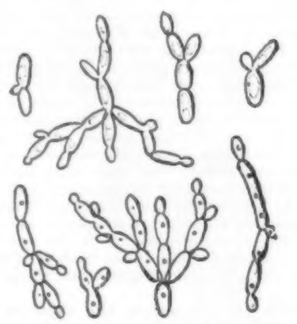


FIG. 8.—S. MYCODERMA. (Reess.)

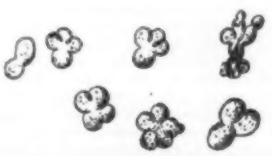


FIG. 9.—S. CONGLOMERATUS. (Reess.)
(It is doubtful whether this is a distinct species.)

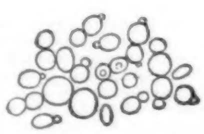


FIG. 10.—TORULA. (Pasteur.)

The publication of Reess' book, in the year 1870,* may be said to have left the question of ascospore formation in much the same position as Caignard de Latour's research left the matter of yeast sprouting. A great discovery was made, but its significance was not appreciated, nor were its salient features clearly set forth, and the work was involved in much error. It was in this condition when it was taken in hand by Hansen, the director of the physiological laboratory at the world-renowned brewery near Copenhagen.

It is wholly unnecessary to preface a review of his investigations by any words of praise. A fair and unbiased consideration of the study and care they have involved, and the practical results they bid fair to produce, should constitute a far more valuable eulogium than any other that could be passed upon them. His first treatise on the subject was published in the year 1876, although he had for some time previously been perfecting his methods and confirming his experiments. Since then he has devoted himself wholly and uninterruptedly to the task, and has even now, after twelve years of incessant labor, by no means completed it. From this statement some idea may be formed of the difficulties he has encountered.

His first endeavor was to operate with pure cultures, for he differed altogether from those who denied their value. The method of Pasteur, whereby a sterilized wort was prepared, and cultivations carried on under conditions which prevented the advent of "*ferments de maladie*," were perfect in their way, and Hansen has not modified them in any really essential particular. But once Reess had established the fact that yeast does not represent a transition stage in the life history of a group of fungi, and that saccharomyces constitute a group of their own with typified and definite species, the question naturally arose as to whether varieties of these species might not likewise exist, and whether they might not be capable by their presence of materially influencing the practical workings of the brewer, the distiller, and the producer of bakers' yeast. If, for instance, we take the familiar example of the geranium, we not only see how many cultivated varieties it contains, but what wide and important differences exist between them in point of view of appearance of foliage, of flowers, and of odors. Some are dwarf in growth, others will climb up the side of a house; some have green leaves, others have variegated leaves of the brightest hue; some smell of lemon, some of pepper, and others do not smell at all, and yet they are all geraniums. Now, since yeast is a plant, why should it not similarly exhibit varieties with differences as great as those indicated above? Why should these differences not exert a material influence upon the beer, bread, or spirit which it is instrumental in producing? How is it possible to determine whether such varieties do exist in commercial yeast, whether they exert a deleterious influence on the product, and if so, how may they best be eradicated? To one and all of these questions neither Pasteur's experiments nor those of Reess afford any reliable answer; indeed, it may be regarded as certain that the saccharomyces with which they worked were mixtures of varieties, if not of species, and that although the preponderance of any one of them might, in the Darwinian sense, have tended to crowd out the weaker, still the latter might have remained in sufficient quantity to exercise a marked effect upon the observed results.

(To be continued.)

* Bot. Unters. u. d. Alkoholgahrungspilze, von Dr. Max Reess, Leipzig, 1870.

[REPORT OF THE LANCET SPECIAL COMMISSION.]

DANGERS ATTENDING LABOR IN THE LONDON DOCKS.

THE evidence relating to the work of dock laborers and stevedores given before the Royal Commission on Sweating has led us to push the inquiry further. We have, for many years past, heard a great deal of the distress and poverty attendant on dock labor. The fearful rush at the dock gates of half-starved men, fighting for the privilege of working for fourpence an hour, has often been described. The insufficient pay, the irregularity of employment, the long hours wasted waiting in the cold and the wet at the dock gates, are all familiar grievances. But the public does not yet fully realize the grave dangers to health, life, and limb which the dock laborer incurs when finally he does obtain employment. The more this phase of the question is studied, the more evident it becomes that human life is needlessly sacrificed. Nor is it one or two accidents here and there that testify to this indifference. Appalling though it may seem, it is, nevertheless, a fact that accidents are the rule, those who escape injury the exception. We asked Mr. Tillet, who gave evidence before the Royal Commission on the subject, and who is seeking to organize a union of dock laborers, how many out of a hundred dock laborers would say in the course of five years' constant employment, suffer from some severe accident. He replied that there were no statistics on the subject. His answer was but a guess based on long experience of dock life, but he was anxious not to exaggerate, and, therefore, would say that in the course of five years' work half the men, at least, would be wounded or otherwise injured.

With all due respect to Mr. Tillet, we considered this answer an unintentional exaggeration, and, to test the matter, went to the Poplar Hospital, where the largest proportion of cases of dock accidents are received. We put exactly the same question to the house surgeon, and, much to our surprise, he went even further than Mr. Tillet. In his opinion, during the course of five years' constant work, out of a hundred men the majority would suffer some accident; in fact, hardly any would escape. From the hospital we proceeded to a small meeting of dock laborers, and propounded the same question, receiving the same answer. The proportion of accidents in five years would certainly be more than fifty per cent. We then put this estimate to the test by asking all the dock laborers present who had themselves been hurt to raise their hands, defining an accident as an injury which compelled the sufferer to leave off work for at least several days. Twenty hands were immediately raised, but when we asked how many had not suffered such accidents, only nine hands were shown. Thereupon one of the dock laborers sprang to his feet and ruefully explained that though he had raised but one hand, he had himself suffered from six accidents; he had fallen three times into the hold of a ship. Then, on another occasion, he fell from a ship's side into a barge; for his fifth accident, he slipped, fell into the water, and was nearly drowned; and, finally, a bale of cotton weighing three hundredweight came down on his head, and he had suffered pains in the neck ever since. Other dock laborers rose and explained how they had been present when two fellow workers were killed outright. Thus, whatever may be the exact proportion of accidents, there is not the slightest doubt as to their appalling frequency.

We now proceeded to inquire what were the principal causes of accidents. The medical evidence went to show that the cases of rupture, which are very frequent, usually occur with men whose general condition may be described as below par. It seems very obvious that if the dock laborers were in the enjoyment of the health and vigor nature intended them to possess, the cases of rupture would be comparatively scarce. But when, after a long period of depression and distress, a man attempts, though his vital powers are impaired by insufficient food, to perform the extremely hard work of loading or unloading a ship, it is not surprising that physical efforts for which he is unfit result in rupture. But many other accidents occur from the same cause. Men who look strong, who might be strong, are weak through want, and when, at last, they get work, accidents occur from sheer lack of muscular force.

We found many such cases. One patient, for instance, is at the present moment under treatment at the Poplar Hospital. He is an elderly man. His knee is severely injured. He had obtained three days' work at the docks during the course of the last three months. His wife earns a shilling a day, and on this small sum the family has had to live. When at last this man got work at the docks, he had to move some barrels of apples, but he was so weak that a barrel rolled over him. He was brought to the hospital in a very emaciated condition.

Often men are taken to the hospital who have fainted away at their work. They are almost pulseless. These cases are clearly the result of excessive physical effort and insufficient food. This is a phase of the subject on which the laborers are very reticent. They naturally do not like to confess that they have insufficient food and are weak, as this, if known, would render it much more difficult for them to obtain employment.

The general impression prevails that the accidents, though now so frequent, are for the most part preventable. The reckless speed at which the work is done is one of the chief causes of disaster. It seems as if no

value were set upon human life. The number of men engaged is often altogether insufficient, hence an excessive strain.

At the present moment, in one of the docks, gangs of two men only are employed for piling sacks of wheat weighing two and a half hundredweight. To make this safe, four men should be enrolled for such work. Again, in another of the docks, there is some very heavy machinery to carry. The ground is often slippery from frost or mud. A man will, therefore, at times make a false step, slip, and be crushed by his own load. The planks also from the quay to the ship are sometimes too narrow and too flexible. The carrying of a heavy weight on a narrow and springy plank barely more than a foot wide frequently results in accidents. The planks should be not less than two feet wide, and much thicker. Many complaints were made to us concerning the "gangers," or a sort of foremen, who are always urging the men forward. The fear lest they should be discharged, and perhaps insufficient food, sometimes render the men so nervous that they make mistakes, and accidents ensue which certainly would be avoided if the work had been done calmly and without such fearful pressure.

A great number of the accidents are due to the careless or hasty slinging of the goods. A set of bags are piled, the chain placed round them, and they are then lifted from the hold of the ship by the crane. If these are not evenly balanced and firmly tied together, they will fall out of the chain and perhaps strike some of the men below. This also occurs if the goods hit the side of the hatch. A man stands at the hatch to shout when the chain should be lifted or lowered, and to warn those below when anything is falling. On this individual depends the life and safety of the workers. Yet, in spite of his responsible position, he receives no extra pay. Sometimes it is even an old man, probably not strong enough to seize the chain and prevent the goods striking the side of the hatch. Like every one else, he is interested in hurrying the work forward, while, on the contrary, it should be his mission to check all undue haste. Much might be done to reduce the risk of dock labor if a different set of hatchway men were appointed. They should be well paid, and made to feel the responsibility of their position. The question suggests itself, therefore, whether their appointment should not be independent of the shipowners, the dock companies, and the laborers, for it should be the duty of these hatchway men to hold all three in check, and insist that the work be done slowly enough to make it safe.

At other times accidents are due to default of gearing. The chains are not greased, they rust and break. There is a man at the Poplar Hospital now whose thigh was fractured by some iron pipes, which struck him because the slings were not chained. Many dock laborers suffer from injury of the spine. They do not notice this at first. They imagine, after some unusual efforts, that they have a "crick in the back," and attribute it to rheumatism, but in time they discover that it is the spine which is permanently injured. Thus we find a number of men who appear strong, who were strong, reduced to the necessity of seeking for only light work. Competition, the desire for cheapness, the struggle for profits, seem to have wrought their worst in the docks. Here men have been known to work for 2½d. an hour. Here men faint from overexhaustion and want of food. Here lives are needlessly squandered. Men are ruptured, their spines injured, their bones broken, and their skulls fractured, so as to get ships loaded and unloaded a little quicker and a little cheaper.

In other departments of enterprise the commercial greed of this century has produced the same callous indifference for human life, but the state, sooner or later, has interfered to protect the weak and helpless. Those who frequent the docks must know that there are laws, for instance, to protect the lives of emigrants. These laws limit the competition between the lines of steamers, so that in seeking to undersell each other, the shipowners should not overcrowd and underfeed the emigrants. The question now arises whether some other law will not be necessary, dealing with ship-owners, dock companies, and the contractors or sweaters in their employ, in such a manner as to prevent the loss of life and limb that undoubtedly results from excessive competition in the rapid loading and unloading of ships.

[Continued from SUPPLEMENT, No. 680, page 10868.]

THE GASES OF THE BLOOD.*

By Prof. JOHN GRAY MCKENDRICK, M.D.

III.

THE next step was the discovery of the important part performed in respiration by the coloring matter of the red blood corpuscles. Chemically, these corpuscles consist of about 30 or 40 per cent. of solid matter. These solids contain only about 1 per cent. of inorganic salts, chiefly those of potash; while the remainder are almost entirely organic. Analysis has shown that 100 parts of dry organic matter contain of hæmoglobin, the coloring matter, no less than 90·54 per cent.; of proteid substances, 8·67; of lecithin, 0·54; and of cholesterine, 0·25. The coloring matter, hæmoglobin, was first obtained in a crystalline state by Funke in 1853, and subsequently by Lehmann. It has been analyzed by Hoppe-Seyler and Carl Schmidt, with the result of showing that it has a perfectly constant composition. Hoppe-Seyler's analysis first appeared in 1868. It is now well known to be the most complicated of organic substances, having a formula, as deduced, from the analyses I have just referred to, by Preyer (1871), of

$$C_{600}H_{960}N_{154}FeS_3O_{179}.$$

In 1862, Hoppe-Seyler noticed the remarkable spectrum produced by the absorption of light by a very dilute solution of blood. Immediately thereafter, the subject was investigated by Prof. Stokes, of Cambridge, and communicated to the Royal Society in 1864. If white light be transmitted through a thin stratum of blood, two distinct absorption bands will be seen. One of these bands next D is narrower than the other, has more sharply defined edges, and is undoubtedly blacker. "Its center," as described by Dr. Gamgee ("Physiological Chemistry," p. 97), "corresponds with wave length 579*, and it may conveniently be distinguished as the absorption band, *a*, in the spectrum of oxyhæmoglobin. The second of the absorption bands—that is, the one next to E—which we shall designate *β*, is broader, has less sharply defined edges, and is not so dark as *a*. Its center corresponds approximately to wave length 553·8. On diluting very largely with water, nearly the whole of the spectrum appears beautifully clear, except where the two absorption bands are situated. If dilution be pursued far enough, even these disappear; before they disappear they look like faint shadows obscuring the limited part of the spectrum which they occupy. The last to disappear is the band *a*. The two absorption bands are seen most distinctly when a stratum of 1 cm. thick of a solution containing 1 part of hæmoglobin in 1,000 is examined; they are still perceptible when the solution contains only 1 part of hæmoglobin in 10,000 of water."

Suppose, on the other hand, we begin with a solution of blood in ten times its volume of water; we then find that such a solution cuts off the more refrangible part of the spectrum, leaving nothing except the red, "or, rather, those rays having a wave length greater than about 600 millionths of a millimeter." On diluting further, the effects, as well described by Prof. Gamgee, are as follows: "If now the blood solution be rendered much more dilute, so as to contain 8 per cent. of hæmoglobin, on examining a spectrum 1 centimeter wide the spectrum becomes distinct up to Fraunhofer's line D (wave length 589)—that is, the red, orange, and yellow are seen, and in addition also a portion of the green, between *b* and F. Immediately beyond D, and between it and *b*, however (between wave lengths 595 and 518), the absorption is intense."

These facts were observed by Hoppe-Seyler. Prof. Stokes made the very important contribution of observing that the spectrum was altered by the action of reducing agents. Hoppe-Seyler had observed that the coloring matter, so far as the spectrum was concerned, was unaffected by alkaline carbonates, and caustic ammonia, but was almost immediately decomposed by acids, and also slowly by caustic fixed alkalies, the colored product of decomposition being hæmatin, the spectrum of which was known. Prof. Stokes was led to investigate the subject from its physiological interest, as may be observed on quoting his own words in the classical research already referred to. "But it seemed to me to be a point of special interest to inquire whether we could imitate the change of color of arterial into that of venous blood, on the supposition that it arises from reduction."

He found that—

"If to a solution of proto-sulphate of iron enough tartaric acid be added to prevent precipitation by alkalies, and a small quantity of the solution, previously rendered alkaline by either ammonia or carbonate of soda, be added to a solution of blood, the color is almost instantly changed to a much more purple red as seen in small thicknesses, and a much darker red than before as seen in greater thickness. The change of color which recalls the difference between arterial and venous blood is striking enough, but the change in the absorption spectrum is far more decisive. The two highly characteristic dark bands seen before are now replaced by a single band, somewhat broader and less sharply defined at its edges than either of the former, and occupying nearly the position of the bright band separating the dark bands of the original solution. The fluid is more transparent for the blue and less so for the green than it was before. If the thickness be increased till the whole of the spectrum more refrangible than the red be on the point of disappearing, the last part to remain is green, a little beyond the fixed line *b*, in the case of the original solution, and blue some way beyond F, in the case of the modified fluid."

From these observations, Prof. Stokes was led to the important conclusion that—

"The coloring matter of blood, like indigo, is capable of existing in two states of oxidation, distinguishable by a difference of color and a fundamental difference in the action on the spectrum. It may be made to pass from the more to the less oxidized by the action of suitable reducing agents, and recovers its oxygen by absorption from the air."

To the coloring matter of the blood Prof. Stokes gave the name of cruorine, and described it in its two states of oxidation as scarlet cruorine and purple cruorine. The name hæmoglobin, given to it by Hoppe-Seyler, is generally employed. When united with oxygen it is called oxyhæmoglobin, and when in the reduced state it is termed reduced hæmoglobin, or simply hæmoglobin.

The spectroscopic evidence is, therefore, complete. Hoppe-Seyler, Hufner, and Preyer have shown also that pure crystallized hæmoglobin absorbs and retains in combination a quantity of oxygen equal to that contained in a volume of blood holding the same amount of hæmoglobin. Thus, 1 gramme of hæmoglobin absorbs 1·56 cubic centimeter of oxygen at 0° C. and 760 millimeters pressure; and, as the average amount of hæmoglobin in blood is about 14 per cent., it follows that $1·56 \times 14 = 21·8$ cubic centimeters of oxygen would be retained by 100 cubic centimeters of blood. This agrees closely with the fact that about 20 volumes of oxygen can be obtained from 100 volumes of blood. According to Pflüger, arterial blood is saturated with oxygen to the extent of nine-tenths, while Hufner gives the figure at fourteen-fifteenths. By shaking blood with air, its oxygen contents can be increased to the extent of from 1 to 2 volumes per cent.

These important researches, the results of which have been amply corroborated, have given an explanation of the function of the red blood corpuscles as regards respiration. The hæmoglobin of the venous blood in the pulmonary artery absorbs oxygen, becoming oxyhæmoglobin. This is carried to the tissues, where the oxygen is given up, the hæmoglobin being reduced. Thus, the coloring matter of the red blood corpuscles is constantly engaged in conveying oxygen from the lungs to the tissues. Probably the union of hæmoglobin with oxygen, and its separation from it, are examples of dissociation—that is, of a chemical decomposition or synthesis, effected entirely by physical conditions; but data regarding this important question are still wanting. If the union of oxygen with the coloring matter is an example of oxidation, it must be attended with the evolution of heat, but, so far as I know, this has not been measured. In co-operation with my friend, Mr. J. T. Bottomley, I have recently been able to detect, by means of a thermo-electric arrangement, a rise of temperature on the formation of oxyhæmoglobin. We mean to prosecute our researches in this direction. If heat were produced in considerable amount, the arterial blood returned from the lungs to the left auricle would be hotter than the blood brought to the right auricle by the veins. This, however, is not the case, as the blood on the right side of the heart is decidedly warmer than the blood on the left—a fact usually accounted for by the large influx of warm blood coming from the liver. The heat exchanges in the lungs are of a very complicated kind. Thus, heat will be set free by the formation of oxyhæmoglobin; but, on the other hand, it will be absorbed by the escape of carbonic acid, and by the formation of aqueous vapor, and a portion will be used in heating the air of respiration. The fact that the blood in the left auricle is colder than that of the right auricle is, therefore, the result of a complicated series of heat exchanges, not easy to follow.

Our knowledge as to the state of the carbonic acid in the blood is not so reliable. In the first place, it is certain that almost the whole of the carbonic acid which may be obtained exists in the plasma. Defibrinated blood gives up only a little more carbonic acid than the same amount of serum of the same blood. Blood serum gives up to the vacuum about 30 volumes per cent. of carbonic acid; but a small part—according to Pfluger, about 6 volumes per cent.—is given up only after adding an organic or mineral acid. This smaller part is chemically bound, just as carbonic acid is united to carbonates, from which it can be expelled only by a stronger organic or mineral acid. The ash of serum yields about one-seventh of its weight of sodium; this is chiefly united to carbonic acid to form carbonates, and a part of the carbonic acid of the blood is united to those salts. It has been ascertained, however, that defibrinated blood, or even serum containing a large number of blood corpuscles, will yield a large amount of carbonic acid, even without the addition of an acid. Thus, defibrinated blood will yield 40 volumes per cent. of carbonic acid—that is, 34 volumes which would be also given up by the serum of the same blood (without an acid), and 6 volumes which would be yielded after the addition of an acid. Something, therefore, exists in defibrinated blood which acts like an acid in the sense of setting free the 6 volumes of carbonic acid. Possibly the vacuum may cause a partial decomposition of a portion of the hæmoglobin, and, as suggested by Hoppe-Seyler, acid substances may thus be formed.

But what is the condition of the remaining 30 volumes per cent. of carbonic acid which are obtained by the vacuum alone? A portion of this is probably simply absorbed by the serum; this part escapes in proportion to the decrease of pressure, and it may be considered to be physically absorbed. A second part of this carbonic acid must exist in chemical combination, as is indicated by the fact that blood serum takes up far more carbonic acid than is absorbed by pure water. On the other hand, this chemical combination is only a loose one, because it is readily dissolved by the vacuum. There can be no doubt that a part of this carbonic acid is loosely bound to carbonate of soda, Na_2CO_3, in the serum, probably to acid carbonate of soda, $NaHCO_3$. This compound exists only at a certain pressure. On a fall of pressure, it decomposes into sodium carbonate and carbonic acid, the latter becoming free. A third part of this carbonic acid is probably loosely bound chemically to disodium phosphate, Na_2HPO_4, a salt which also occurs in the blood serum. Fernet has shown that it binds two molecules of carbonic acid to one molecule of phosphoric acid. This salt occurs in considerable quantity only in the blood of carnivora and omnivora, while in that of herbivora, such as in the ox and calf, only traces exist. It cannot be supposed in the latter instances to hold much carbonic acid in chemical combination. There must exist, therefore, other chemical substances for the attachment of the carbonic acid of the blood, and it has been suggested that a part may be connected with the albumen of the plasma.

According to Zuntz, the blood corpuscles themselves retain a part of the carbonic acid, as the total blood is able to take up far more carbonic acid out of a gaseous mixture rich in carbonic acid, or consisting of pure carbonic acid, than can be absorbed by the serum of the same quantity of blood. No compound, however, of carbonic acid with the blood corpuscles is known.

The nitrogen which is contained in the blood to the amount of from 1·8 to 2 volumes per cent. is probably simply absorbed, for even water is able to absorb to 2 volumes per cent. of this gas.

If we then regard the blood as a respiratory medium having gases in solution, we have next to consider what is known of the breathing of the tissues themselves. Spallanzani was undoubtedly the first to observe that animals of a comparatively simple type used oxygen and gave up carbonic acid. But he went further, and showed that various tissues and animal fluids, such as the blood, the skin, and portions of other organs, acted in a similar way. These observations were made before the beginning of the present century, but they appear to have attracted little or no attention until the researches of Georg Liebig on the respiration of muscle, published in 1850. He showed that fresh muscular tissue consumed oxygen and gave up carbonic acid. In 1856, Matteucci made an important advance, by observing that muscular contraction was attended by an increased consumption of oxygen and an increased elimination of carbonic acid. Since then, Claude Bernard and Paul Bert, more especially the latter, have made numerous observations regarding this matter. Paul Bert found that muscular tissue has the greatest absorptive power. Thus we arrive at the grand conclusion that the living body is an aggregate of living particles, each of which breathes in the respiratory medium passing from the blood.

As the blood, containing oxygen united with the coloring matter (hæmoglobin), passes slowly through the capillaries, fluid matter transudes through the

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* Address to the British Medical Association at its annual meeting at Glasgow. Delivered on August 10 in the Natural Philosophy class-room, University of Glasgow, by John Gray McKendrick, M.D., LL.D., F.R.SS.L. and E., F.R.C.P.E., Professor of the Institutes of Medicine in the University of Glasgow.—*Nature.*

* Dr. Gamgee gives the measurements of the wave lengths in millionths, not in ten-millionths of a millimeter.

walls of the vessels, and bathes the surrounding tissues. The pressure or tension of the oxygen in this fluid being greater than the tension of the oxygen in the tissues themselves, in consequence of the oxygen becoming at once a part of the living protoplasmic substance, oxygen is set free from the hæmoglobin, and is appropriated by the living tissues, becoming part of their protoplasm. While alive, or at all events while actively discharging their functions, as in the contraction of a muscle, or in those changes we term secretion in a cell, the living protoplasm undergoes rapid decomposition, leading to the formation of comparatively simple substances. Among these is carbonic acid. As it has been ascertained that the tension of the carbonic acid in the lymph is less than its tension in venous blood, it is difficult at first sight to account for the absorption of carbonic acid by venous blood; but its tension is higher than that of carbonic acid in arterial blood, and it must be remembered that the lymph has had the opportunity, both in the connective tissue and in the lymphatic vessels, of modifying its tension by close contact with arterial blood. Strassburg fixes the tension of the carbonic acid in the tissues as equal to 45 mm. of mercury, while that of the venous blood is only 41 mm. We may assume that as the carbonic acid is set free, it is absorbed by the blood, uniting loosely with the carbonates and phosphates of that fluid, thus converting it from the arterial into the venous condition. This constitutes respiration of tissue.

In connection with the respiration of tissue, as determined by the analysis of the blood gases and of the gases of respiration, there arises the interesting question of the ratio between the amount of oxygen absorbed and the amount of carbonic acid produced, and very striking contrasts among animals have thus been determined. Thus in herbivora the ratio of the oxygen absorbed to the carbonic acid produced, or the respiratory quotient, as it is termed by Pfluger, $\frac{CO_2}{O}$ amounts to from 0·9 to 1·0, while in carnivora it is from 0·75 to 0·8. Omnivora, of which man may be taken as the example, come between $\frac{CO_2}{O} = 0·87$. The quotient is greater in proportion to the amount of carbohydrate in the diet, whether the animals are carnivora, herbivora, or omnivora. The respiratory quotient becomes the same, about 0·75, in starving animals, a proof that the oxidations are kept up at the cost of the body itself, or, in other words, the starving animal is carnivorous. The intensity of respiration in different animals is well shown in the following table, in which the amount of oxygen used is given per kilogramme of body-weight per hour (Dr. Immanuel Munk, "Physiologie des Menschen und der Saugethiere," 1888, p. 82).

Animal.	O in grammes.	Respiratory Quotient, $\frac{CO_2}{O}$
Cat	1·007	0·77
Dog	1·183	0·75
Rabbit	0·918	0·92
Hen	1·300	0·93
Small singing birds	11·360	0·78
Frog	0·084	0·63
Cockchafer	1·019	0·81
Man	0·417	0·78
Horse	0·563	0·97
Ox	0·552	0·98
Sheep	0·490	0·98

Smaller animals therefore have, as a rule, a greater intensity of respiration than larger ones. In small singing birds the intensity is very remarkable, and it will be seen that they require ten times as much oxygen as a hen. On the other hand, the intensity is low in cold-blooded animals. Thus a frog requires 135 times less oxygen than a small singing bird. The need of oxygen is therefore very different in different animals. Thus a guinea pig soon dies with convulsions in a space containing a small amount of oxygen, while a frog will remain alive for many hours in a space quite free of oxygen. It is well known that fishes and aquatic animals generally require only a small amount of oxygen, and this is in consonance with the fact that sea water contains only small quantities of this gas. Thus, according to the elaborate researches of my friend, Prof. Dittmar, on the gases of the sea water brought home by the Challenger expedition, collected in many parts of the great oceans, and from varying depths: "The ocean can contain nowhere more than 15·6 c. c. of nitrogen, or more than 8·18 c. c. oxygen per liter; and the nitrogen will never fall below 8·55 c. c. We cannot make a similar assertion in regard to the oxygen, because its theoretical minimum of 4·30 c. c. per liter is liable to further diminution by processes of life and putrefaction and processes of oxidation." (Dittmar, Proceeding of Phil. Soc. of Glasgow, vol. xvi., p. 61). As a matter of fact, a sample of water from a depth of 2,875 fathoms gave only 0·6 c. c. per liter of oxygen, while one from a depth of 1,500 fathoms gave 2·04 c. c. per liter. Taking 15° C. as an average temperature, one liter of sea water would contain only 5·31 c. c. of dissolved oxygen—that is, about 0·5 c. c. in 100 c. c. Contrast this with arterial blood, which contains 20 c. c. of oxygen in 100 c. c. of blood, or there are about forty times as much oxygen in arterial blood as in sea water. At great depths the quantity of oxygen is very much less, and yet many forms of life exist at these great depths. Fishes have been dredged from a depth of 2,750 fathoms, where the amount of oxygen was probably not so much as 0·06 c. c. per 100 c. c., or 300 times less than that of arterial blood. Making allowance for the smaller quantity of oxygen in the blood of a fish than that of a mammal, it will still be evident that the blood of the fish must contain much more oxygen than exists in the same volume of sea water. No doubt we must remember that the water is constantly renewed and that the oxygen in it is in the state of solution, or, in other words, in a liquid state. But the question remains, where do these deep sea creatures obtain the oxygen? Probably by a method of storage. Biot has found in the swimming bladders of such fishes 70 volumes per cent. of pure oxygen, a gas in which a glowing splinter of wood is relit. This oxygen probably oxygenates the blood of the fish when it plunges into the dark and almost airless depths of the ocean.

Aquatic breathers, however, if they live in a medium containing little oxygen, have the advantage that they are not troubled with free carbonic acid. One of the most striking facts discovered by the Challenger chemists is that sea water contains no free carbonic acid, except in some situations where the gas is given off by volcanic action from the crust of the earth forming the sea bed. In ordinary sea water there is no free carbonic acid, because any carbonic acid formed is at once absorbed by the excess of alkaline base present. Thus the fish breathes on the principle of Fleuss' diving apparatus, in which the carbonic acid formed is absorbed by an alkaline solution. There is nothing new under the sun. The fish obtains the oxygen from the sea water, no doubt, by the chemical affinity of its hæmoglobin, which snatches every molecule of oxygen it may meet with, while it gets rid of its carbonic acid easily, because there is not only no tension of carbonic acid in the sea water to prevent its escape, but there is always enough of base in the sea water to seize hold of the carbonic acid the moment it is formed. If we could get rid of the carbonic acid of the air of expiration as easily, we could live in an atmosphere containing a much smaller percentage of oxygen.

(To be continued.)

[Continued from SUPPLEMENT, No. 680, page 10863.]

RADII OF CURVATURE GEOMETRICALLY DETERMINED.

By Prof. C. W. MACCORD, Sc.D.

NO. X.—THE LEMNISCATE OF BERNOUILLI.

IN Fig. 32, C and D are two fixed centers, about which turn the two levers A C, B D, having their free ends connected by the link A B, prolonged to carry a pencil at P. Let C D be equal to B D, and let A B, A P, each be equal to the shorter lever A C, then the pencil will trace the symmetrical curve shown, the beautiful lemniscate of Bernouilli.

With these proportions it will presently appear that this combination has some very remarkable features: but before discussing these, it may be as well to point out the fact, that it is only a special case of a very familiar arrangement; by comparison with Fig. 33, it will be seen that in no particular except the proportions does it differ from the combination consisting of the walking beam, connecting rod, and crank of the common river boat engine. In this second diagram, as in the first, we have made A P = A C, so that the resulting path of P still passes through C; but it is not symmetrical with respect to C D or indeed to any other line.

And Fig. 33, again, differs from the ordinary directing stationary engine movement only in this, that the end B of the connecting rod travels in a circular arc instead of in a right line passing through C. That movement, and the path of a point upon the connecting rod, have been discussed already in Article No. VII. of this series (SCI. AM. SUPPL. No. 595); and the methods there explained may be applied in this case also. One special feature may be noted in the construction of Fig. 33, viz.: that the length of A B is taken equal to the common tangent of the circular paths of the points A and B, the result being that the radius of curvature at P is infinite.

Returning now to Fig. 32; the limits of the travel of B are at once found by cutting its path at E and F, by arcs described about C, with a radius equal to A C + A B, or 2 A C: draw C E cutting the path of A in the point I; then when A is at I, we have an outward dead center at that point, and the pencil P will be at C. Supposing, then, the crank A C to go to the left, it will be readily seen that the pencil will trace the curve C P M; and if it go to the right, that the curve C P′ N will be described. Now, in order to show that these curves are similar, draw B D in any intermediate position at pleasure, and also A C, B A P, the corresponding positions of the crank and the link.

Draw B C cutting the path of A in O, and set off O A′ = O A; draw B A′ P′ = B A P, and join C A′; if we suppose these last two lines to be a link and a second crank, we have a system identical with the common jointed pantagraph, and since the triangle P B P′ is always isosceles, B C, which bisects the angle at B, will always bisect and be perpendicular to the base P C P′.

The points P and P′, then, will always be symmetrically situated with respect both to the point C and the line M C N. And, moreover, the tangents at these points will be parallel; for producing A C, B D, to intersect in H, that point is the instantaneous axis of P A B, and P H is the normal at P; in like manner, C A′ produced cuts B D in H′, and P′ H′ is the normal at P′. Now produce the right lines P C P′ and B D to intersect in S, then by reason of the parallels C H, P′ B, we have the proportion

$$\frac{SH}{SB} = \frac{SC}{SP'};$$

and from the parallels P B, C H′, we have

$$\frac{SB}{SH'} = \frac{SP}{SC};$$

when by multiplication,

$$\frac{SH}{SH'} = \frac{SP}{SP'};$$

therefore the normals P H, P′ H′, are parallel, and consequently the tangents are parallel also.

It is obvious that the length M N of the lemniscate will always be four times A C; its breadth, and the position of the point at which the breadth will be greatest, depend upon the location of D, and the consequent length of B D; in a manner illustrated in Fig. 34. Let P H B in this diagram be an isosceles triangle; bisect P B at A by the perpendicular H A, which produce until A C = A B. Through C draw a right line of indefinite length perpendicular to H P, and produce H B, H P, to cut this perpendicular in D and R; then draw A R, A D, C B, and C P.

Then from similar triangles A H B, R C H, we have

R C H = H B A;

and adding A C B = A B C,

we find that R C B = H B C;

therefore B C D = C B D, whence C D = B D, and A D bisects the angle B D C, as well as the right angle B A C. Consequently, since the bisectors of the three angles of any triangle meet in a common point, A R bisects the angle H R C, whence P R A = C A D; and because A C D = A B D = A P R, the triangles R P A, A C D, are similar, and we have

$$C D : A C :: A P : P R,$$

or

$$B D : A C :: A C : P R.$$

Now, if A C and B D be the levers, and A B the link, the point P will trace the lemniscate, and H being the instantaneous axis in the position here shown, H P will be the normal at P. But by construction H P is perpendicular to the line of centers C D, to which line therefore the tangent is parallel: R P, then, is half the greatest breadth of the lemniscate, and as just shown, it is a third proportional to the two lines B D, A C: which enables us readily to proportion the levers for any given length and breadth; and the position of the greatest ordinate P R is determined by the consideration that P C is equal to the side of the square inscribed in the circle whose radius is A C.

We come now to the determination of the radius of curvature of the lemniscate at various points. If in Fig. 32 we suppose the lever B D to be placed at the limit of its traverse, that is to say at E D, the parts will have the relative positions shown in Fig. 35, the crank being upon an outward dead center, the pencil P coinciding with C.

Assigning to the crank pin I any velocity I V, the pencil will move in the same direction, with the velocity C X = 2 I V. The instantaneous axis, which is at E, will receive, by virtue of the motion I V, a component motion E W, parallel to I V and twice as great. The actual direction of the motion of this axis must be E D, since that lever is at rest, whence the velocity will be E U, determined by drawing W U perpendicular to E W. But this resultant need not be found for the present purpose, which has to do only with that component which is perpendicular to the normal E P. This, as just seen, is equal to C X and in the same direction; W X, then, is parallel to the normal, and the radius of curvature at P is infinite.

The general operation of finding the center of curvature at any point on the curve is shown in Fig. 36. The instantaneous axis of P A B is at H; and if we assign to A a motion of any velocity A V, it will have in the line of the link a component A *a*, to which the components B *b*, P *p*, must be equal. The motion of P must be perpendicular to P H, and its velocity P X is ascertained by drawing at *p* a perpendicular to P B. In like manner, a perpendicular to P B at *b* determines B Y, the absolute motion of B; which would give to the point H of D B produced a motion H F in the same direction, of a velocity determined by drawing D Y and producing it to F. Supposing C A to be for the instant at rest, this motion H F would cause the intersection H to move in the direction and with the velocity H G, determined by drawing at F a perpendicular to H F. Thus we have H G as the component motion of the instantaneous axis, due to the motion of the lever B D. Next, the motion A V will give to the point H of C A the motion H E, perpendicular to C H and limited by the prolongation of C V; which, supposing B D for the instant to be stationary, would cause the intersection H to move in the direction H D, the velocity H J being determined by drawing through E a perpendicular to H E. Having thus the two components H G, H J, the resultant motion of the instantaneous axis is found by completing the parallelogram and drawing the diagonal, H U: resolving this with reference to H P, we have finally the component H W, perpendicular to the normal at P; and drawing W X, we produce it to cut H P produced, in the point O, which is the required center of curvature of the lemniscate at P.

But perhaps the most interesting phases of the combination by which this curve is traced are those presented at the instants when the crank pin A reaches the positions K and L in Fig. 32. In each of these cases the two levers and the link shut up and collapse, as we may say, into the one straight line C D, thus producing a phenomenon not yet met with, viz., the simultaneous occurrence of two dead points.

The situation in the first of these events is shown in Fig. 37; and, the axis of the pin B coinciding with that of the shaft C, it is clear that if the shorter lever be regarded as the driver, the only result will be to carry the link round and round about the center B, the pencil P describing a circle. If, however, the long lever drive, the action becomes perfectly positive, and A C will be compelled to rotate, while the pencil will travel in the lemniscate path.

In order to ascertain the velocity ratio, and to find the radius of curvature at the extremities of the curve, we must first determine the location and motion of the instantaneous axis in this novel position. This may be done by the aid of the diagram Fig. 38. Describe about D a circle with radius B D, and about A another with radius A C, then B C is a common chord. Find the instantaneous axis H, by producing C A, B D; the former cuts the less circumference in G, and the latter, extended from B beyond D, cuts the greater in E. Draw B G, C E; these lines will be parallel, each being perpendicular to B C: consequently,

$$H G : H C :: G B : C E,$$

whence

$$H G : G C :: G B : C E - G B$$

Now it is clear that at the instant when the system collapses, A reaching K, E will be at Q, and G and P will come together at T on the line of centers, T C being equal to G C: therefore at the limit, letting A C = r, and B D = R, we shall have

$$H G : 2r :: 2r : 2R - 2r,$$

or

$$H P = H G = \frac{2r^2}{R - r} \quad \text{.............. (1)}$$

We are thus enabled to determine the distance C H, in the diagram in the lower part of Fig. 37, either graphically or by computation. If then we suppose B to move with any velocity B Y, we have only to draw H Y in order to determine the corresponding velocities of A and P, which are A V and P X respectively, both being perpendicular to C D, as also is B Y itself.

The instantaneous axis, being the vertical intersection of the two lines A C and B D, all points of which are moving at this same time in the same direction,

must also be moving perpendicularly to C D, and its velocity H W may be determined by producing either C V or D Y. Then W X produced cuts the normal in O, the center of curvature.

In Fig. 39 is shown the analogous construction as the crank A C goes to the right from the position of the single outward dead point of Fig. 35: and by reasoning similar to the above, observing that G C is the sum instead of the difference of H G and H C, we find at the limit the value

$$H P = H G = \frac{2 r^2}{R + r} \ldots\ldots\ldots\ldots (2)$$

In Fig. 40 we have a representation of the other position in which there is a double dead point, the diagram constituting the lower part of the figure showing the construction for finding the motions of A and P corresponding to any assigned velocity B Y of the free end of the longer lever, and also the center of curvature O of the lemniscate at its extremity P.

The value of the radius of curvature O P may now be easily found in terms of R and r, either from the expression (1) in connection with Fig. 37, or from (2) in

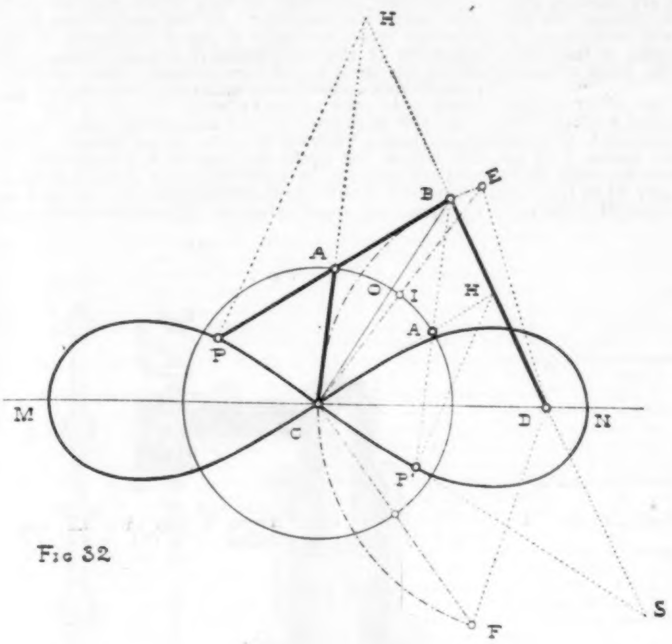


FIG. 32

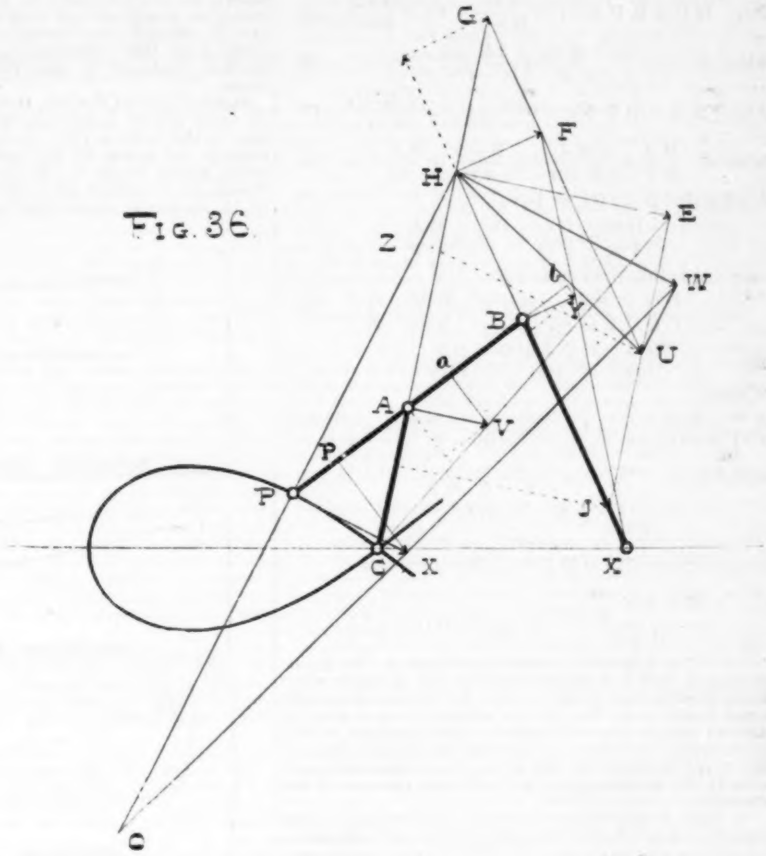


FIG. 36

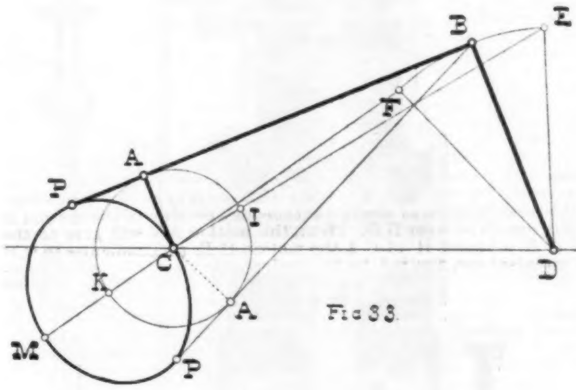


FIG. 33

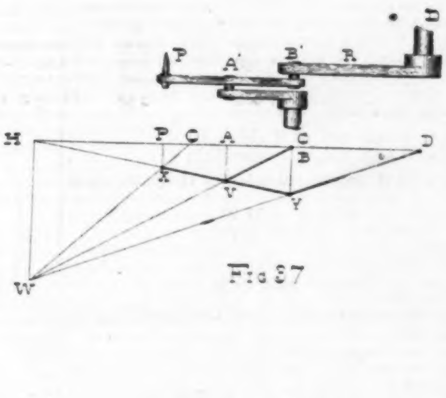


FIG. 37

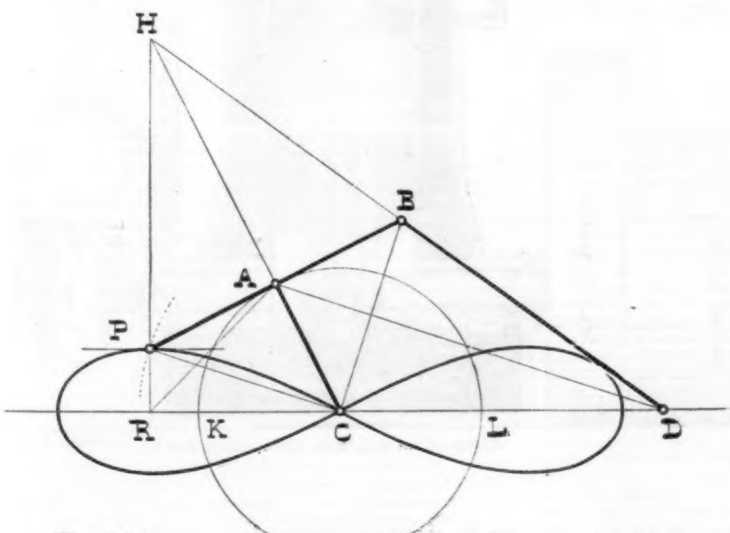


FIG. 34

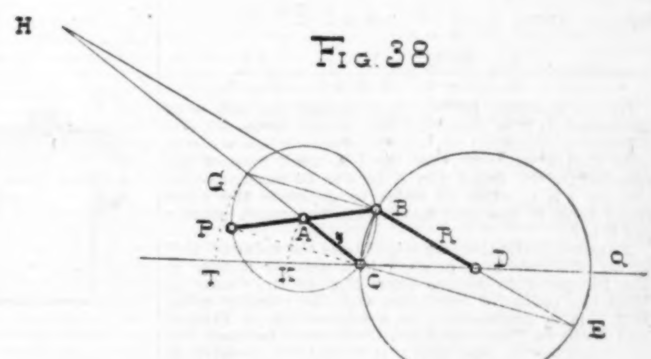


FIG. 38

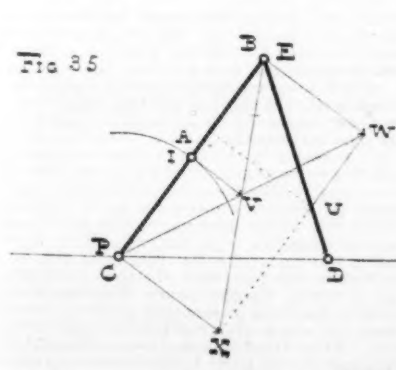


FIG. 35

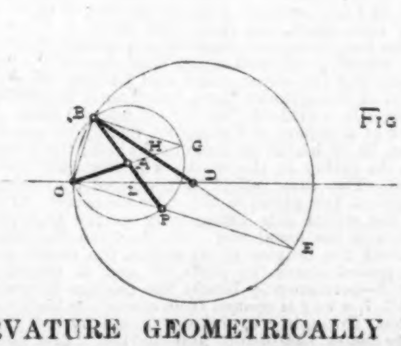


FIG. 39

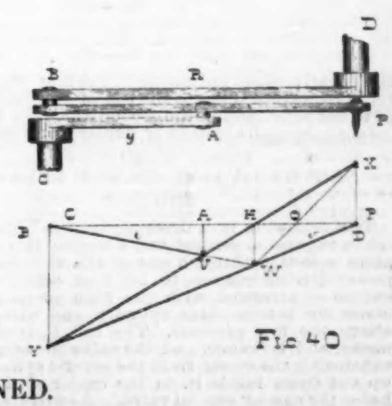


FIG. 40

RADII OF CURVATURE GEOMETRICALLY DETERMINED.

connection with Fig. 40. Making use of the former, we have, in Fig. 37,

$$\frac{\mathrm{H\,W}}{\mathrm{A\,V}} = \frac{\mathrm{H\,C}}{r} \ldots\ldots\ldots\ldots\ldots (3)$$

and

$$\frac{\mathrm{A\,V}}{\mathrm{P\,X}} = \frac{\mathrm{H\,A}}{\mathrm{H\,P}} \ldots\ldots\ldots\ldots\ldots (4)$$

But $\mathrm{H\,C} = \mathrm{H\,P} + 2\,r = \frac{2\,r^2}{\mathrm{R} - r} + 2\,r = \frac{2\,r\,\mathrm{R}}{\mathrm{R} - r} \ldots (5)$

whence

$$\frac{\mathrm{H\,C}}{r} = \frac{2\,\mathrm{R}}{\mathrm{R} - r} \ldots\ldots\ldots\ldots\ldots (6)$$

Also, $\mathrm{H\,A} = \mathrm{H\,P} + r = \frac{2\,r^2}{\mathrm{R} - r} + r = \frac{r\,(\mathrm{R} + r)}{\mathrm{R} - r} \ldots (7)$

whence $\frac{\mathrm{H\,A}}{\mathrm{H\,P}} = \frac{r\,(\mathrm{R} + r)}{\mathrm{R} - r} \times \frac{\mathrm{R} - r}{2\,r^2} = \frac{\mathrm{R} + r}{2\,r} \ldots\ldots (8)$

Multiplying (3) by (4), we have

$$\frac{\mathrm{H\,W}}{\mathrm{P\,X}} = \frac{\mathrm{H\,O}}{\mathrm{P\,O}} = \frac{\mathrm{H\,C}}{r} \times \frac{\mathrm{H\,A}}{\mathrm{H\,P}},$$

or, substituting from (6) and (8),

$$\frac{\mathrm{H\,O}}{\mathrm{P\,O}} = \frac{2\,\mathrm{R}}{\mathrm{R} - r} \times \frac{\mathrm{R} + r}{2\,r} = \frac{\mathrm{R}\,(\mathrm{R} + r)}{r\,(\mathrm{R} - r)} \ldots\ldots (9)$$

But

$$\frac{\mathrm{H\,O}}{\mathrm{P\,O}} = \frac{\mathrm{H\,P} + \mathrm{P\,O}}{\mathrm{P\,O}} = \frac{\mathrm{H\,P}}{\mathrm{P\,O}} + 1,$$

whence

$$\frac{\mathrm{H\,P}}{\mathrm{P\,O}} = \frac{\mathrm{R}\,(\mathrm{R} + r)}{r\,(\mathrm{R} - r)} - 1 = \frac{\mathrm{R}^2 + r\,\mathrm{R} - r\,\mathrm{R} + r^2}{r\,(\mathrm{R} - r)} = \frac{\mathrm{R}^2 + r^2}{r\,(\mathrm{R} - r)}$$

which gives

$$\frac{1}{\mathrm{P\,O}} = \frac{\mathrm{R}^2 + r^2}{r\,(\mathrm{R} - r)\,.\,\mathrm{H\,P}},$$

or

$$\mathrm{P\,O} = \frac{r\,(\mathrm{R} - r)\,.\,\mathrm{H\,P}}{\mathrm{R}^2 + r^2};$$

substituting value of H P in (1), this becomes

$$\frac{r\,(\mathrm{R} - r) \times \frac{2\,r^2}{\mathrm{R} - r}}{\mathrm{R}^2 + r^2}, \text{ or, finally, } \mathrm{P\,O} = \frac{2\,r^3}{\mathrm{R}^2 + r^2}.$$

But of still greater interest, perhaps, is the determination of the velocity ratios at the instants when these double dead points occur. In the case of a single dead point, as in Fig. 35, the velocity ratio is that of zero to infinity; by reference to that diagram it will be obvious that whatever the velocity assigned to A C, the lever B D will at the instant be stationary; and also, it will be noted that A C only can be used as the driver.

In Figs. 37 and 40, on the other hand, while it is still true that if A C be moved with any velocity whatever, no motion will be imparted to B D, it will also be seen that A C cannot be used as a driver, the only result of such an attempt being to carry the link round and round, turning about B, then coincident with C, as a fixed center. But while in Fig. 35 B D cannot be made to drive, in Figs. 37 and 40 it can, and the velocity ratio is finite in each case.

Let v = ang. vel. of R about D,
v' = ang. vel. of r about C;

then if we give to H any linear velocity H W, we shall have

$$v = \frac{\mathrm{H\,W}}{\mathrm{H\,D}},\ v' = \frac{\mathrm{H\,W}}{\mathrm{H\,C}},$$

and

$$\frac{v}{v'} = \frac{\mathrm{H\,C}}{\mathrm{H\,D}} = \frac{\mathrm{H\,C}}{\mathrm{H\,C} + \mathrm{R}}.$$

Now in Fig. 37 we have (Eq. (5) of the preceding investigation),

$$\mathrm{H\,C} = \frac{2\,r\,\mathrm{R}}{\mathrm{R} - r};$$

whence $\mathrm{H\,C} + \mathrm{R} = \frac{2\,r\,\mathrm{R}}{\mathrm{R} - r} + \mathrm{R} = \frac{\mathrm{R}\,(\mathrm{R} + r)}{\mathrm{R} - r};$

consequently $\frac{v}{v'} = \frac{2\,r\,\mathrm{R}}{\mathrm{R} - r} \times \frac{\mathrm{R} - r}{\mathrm{R}\,(\mathrm{R} + r)} = \frac{2\,r}{\mathrm{R} + r}.$

In the position in Fig. 40, although the radius of curvature O P is the same, the velocity ratio is quite different; as indeed we should expect, when we consider that in order to trace the left hand loop of the lemniscate, the crank pin A in Fig. 32 must traverse the arc I K I', while in order to generate the right hand loop it has only to traverse the much shorter arc I' L I.

As above intimated, we might take the value of H P in Eq. (2) above, and proceed in a manner similar to the foregoing to deduce from Fig. 40 the values of both the radius of curvature and the velocity ratio. But this is unnecessary, as a comparison of Figs. 38 and 39 shows that the whole difference between the two cases lies in this, that r, if considered positive in one, should be regarded as negative in the other.

Changing the sign of r, then, in the two expressions in question, they become

$$\mathrm{P\,O} = -\frac{2\,r^3}{\mathrm{R}^2 + r^2};$$

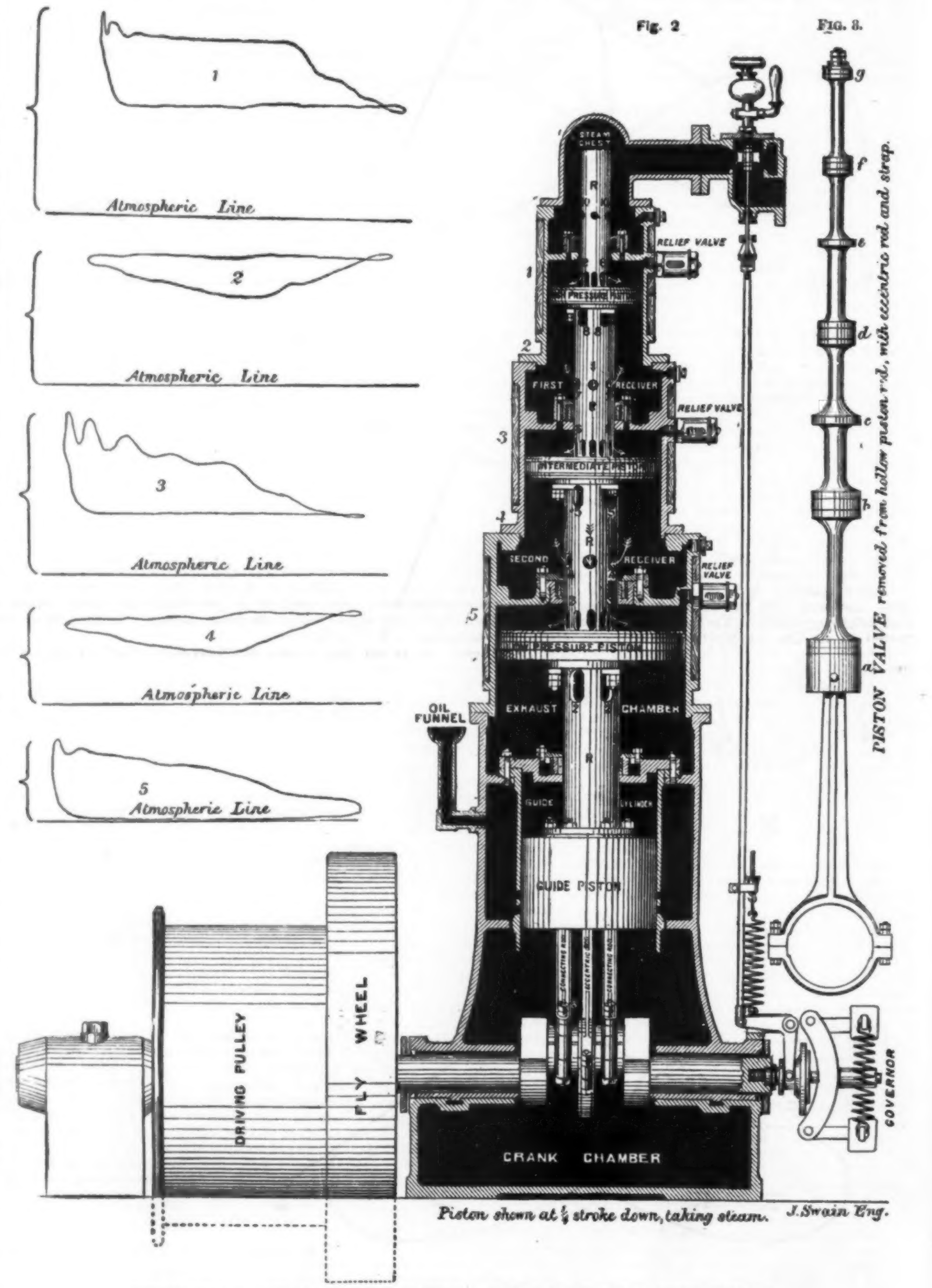
$$\frac{v}{v'} = -\frac{2\,r}{\mathrm{R} - r};$$

the negative signs indicating in the first that the center of curvature O lies to the left of the curve instead of to the right, and in the second that the two levers rotate in opposite instead of similar directions.

CENTRAL VALVE TRIPLE EXPANSION ENGINES.

THE following is a description of a Willans patent triple expansion central valve engine, G size: Fig. 2 gives a section through one of the 40 indicated horse power driving engines, to 1-10·8 of actual size. The engine is arranged with the high pressure cylinder above the intermediate cylinder, and with the latter above the low pressure. The rod, R, is of large diameter, and is hollow, and the valve for admitting and exhausting the steam from the several cylinders works up and down inside it, in the center of the engine—hence the name "central valve." A separate view of the valve is given in Fig. 3. It is driven in the usual way by an eccentric, but, since the valve face—*i. e.*, the inner surface of the hollow rod—moves up and down with the pistons, the source of the valve motion, *i. e.*, the eccentric, must move up and down with the pistons also. This is effected by mounting the eccentric on the crank pin, instead of on the shaft as usual. The ports through which the steam enters and leaves the respective cylinders are simply holes in the hollow rod shown at *e e*, 6, 6, and 3, 3. These are exposed alternately to steam coming from above, through the rod, and to exhaust—also through the rod—downward, according as the corresponding pistons of the valve, marked, *f*, *d*, and *b*, pass below the holes or above them.

Steam enters at the top, through the governor throttle valve shown in section, into the steam chest. The top of the hollow rod, though uncovered, is closed against the steam by the uppermost piston, *g*, of the valve, which works in the part above the holes 10, 10. Steam can therefore enter the rod only when the holes 10, 10, are in the steam chest, as they are when the high



Piston shown at ¾ stroke down, taking steam. J. Swain Eng.

CENTRAL VALVE TRIPLE EXPANSION ENGINES.

pressure piston is near the upper part of its travel. On commencing the down stroke, *f* is just passing below the holes, *e e*, and therefore admits steam into the first or high pressure cylinder by way of 10, 10, and 9, 9; *f* rises again, and closes the ports, 9, 9, when the piston has descended about three quarters of its stroke; but cut-off is effected earlier than this by the holes 10, 10, leaving the steam chest and passing through the gland in the cylinder cover, thus losing their supply of steam. It is evident that cut-off may be made to take place at any part of the stroke, merely by making the holes, 10, 10, higher or lower in the rod; the lower they are, the earlier in the stroke will they leave the steam chest. The same effect is produced by altering the height of the gland in the cylinder cover. After cut-off the steam acts expansively on the high pressure piston in the usual way. By the time the piston has reached the bottom of its stroke, the piston valve, *f*, has passed above the ports, *e e*, and, as the valve, *e*—Fig. 3—permanently blocks the passage between 8, 8, and 7, 7, a way is opened from above the high pressure piston, through *e e*, and out again by 8, 8, into the space below the piston, and marked "first receiver." During the up stroke—effected by the momentum of the fly-wheel only—the steam is merely transferred, practically without change of volume or pressure, into the receiver. The "receiver" might be open to the atmosphere, so as to allow the steam to escape at once, the two lower cylinders with their pistons and valves being omitted. In that case the cycle would be already complete, and in fact the above description would be all the description needed for a Willans "simple" engine, such as would be used where only low pressure steam was available. In the present case, however, the receiver—which is partly composed of the lower end of the high pressure cylinder—forms also the steam chest for another cylinder, which in a compound engine would be the last of a series of two, but which here is the second of three.

At the beginning of the succeeding down stroke steam passes from the receiver, by the holes 7, 7, into the hollow rod again, and out by 6, 6, into the intermediate cylinder, until cut-off occurs by the descent of the holes, 7, 7, through the cylinder cover. On the next up stroke the steam exhausts, just as described above, through 6, 6, and 5, 5, into the second receiver; in the next down stroke it passes into the low pressure cylinder, through 4, 4, and 3, 3; in the next up stroke it is transferred, through 3, 3, and 2, 2, into the "exhaust chamber," which is in communication with atmosphere, but it is not until the third revolution after that in which the steam enters the high pressure cylinder that it is finally expelled from the engine. It will be noticed that the full pressure in the steam chest is constantly acting upon the valve piston, *g*. This insures that the eccentric rod shall be kept constantly pressed against the eccentric, as well as on the up as on the down stroke. With the steam pistons the case is different. They are much heavier, and they are all in equilibrium during the up stroke, for there is at that time communication existing between the upper and lower sides of all of them. Special means, therefore, are required for checking their momentum on the up stroke, so as to keep the connecting rod brasses truly in constant thrust. This object is carried out—without, however, adding any special parts to the engine—by an arrangement which is the subject of a separate patent. The guide, which takes the side thrust of the connecting rod—and is more usually described in ordinary

engines as the crosshead—is in the form of a piston, moving in a cylinder closed at the top; this is shown in Fig. 2. At the bottom of its stroke it uncovers certain holes, *l*, *l*, which place the guide cylinder momentarily in communication with the atmosphere. As there is no other outlet from it, the upward movement of the guide piston compresses the air contained in the guide cylinder, until at the top of the stroke a considerable pressure is reached, sufficient to stop the line of pistons, etc., without shock, and without allowing the upper brass to leave the crank pin. In fact, an air cushion is substituted for the usual steam cushion, and since the pressure at which the compression of the air commences—unlike that of exhaust steam—is always the same irrespective of whether the engine exhausts into the atmosphere or into a vacuum, the cushioning is invariable in its action, and is just as effective in a condensing as in a non-condensing engine. The compressed air gives out its power again on the succeeding down stroke.

It will be seen that where the piston rod passes through the various cylinder covers a gland or stuffing box is formed by cast iron spring rings, similar to piston rings, but springing inward instead of outward. Such rings have been in use for many years in various types of Willans engines, and have been found to keep extremely tight and give no trouble. They apparently offer a perfect solution of the difficulties which attend the use of internal stuffing boxes of ordinary construction.

With Fig. 2 will be found a series of diagrams taken during trials to be referred to. It will be noticed that diagrams are taken from the receivers as well as from the cylinders. The reason is that during the earlier part of the down stroke the pressure in both receivers diminishes, returning approximately to the original pressure at the end. The mean reduction of pressure in the receiver throughout the down stroke is, of course, a reduction in the back pressure against which the piston is working, and is a virtual addition to the power developed in the cylinder above. For this reason the diagrams from the receivers have to be counted in the power. It will be seen that each receiver interposes a most effectual thermal separation between the cylinders; the steam expanding in one cylinder, and expelled thence, does not continue its expansion in the next cylinder of the series until after the lapse of half a revolution. This prevents the temperature in each cylinder from falling below that proper to the pressure shown by the straight line at the bottom of each cylinder diagram. It is claimed that this is an important feature peculiar to the Willans engine. Insuring that the pressures, and therefore the temperatures, recorded in the diagrams from successive cylinders shall never overlap, has, Mr. Willans holds, a great influence upon the thermo-dynamic efficiency of the engine. Mr. Willans maintains that one of the chief causes of inefficiency in steam engines is the existence of a large range of temperature in any one cylinder, *i. e.*, a large difference between the temperatures of the incoming and the outgoing steam. To lessen this range is the object aimed at in the multiplication of cylinders incidental to the compound or triple expansion systems, in which the entire expansion—and fall of temperature—of the steam is carried out in two or three stages instead of in one. In the Willans engine the object is attained more perfectly, it is claimed, than in any other, and the results are correspondingly better; in fact, they approximate to the result, as regards smallness of range of temperature, which would be obtained by using four or even five stages of expansion in an ordinary engine, without the accompanying complication and losses from friction and wire drawing. It may be noticed that two well known "refinements," sometimes supposed to be indispensable in high class engine work, are absent from the Kingston engines, viz., steam jackets and automatic variable expansion gear. As regards the first, it is pointed out that steam jackets are only useful upon cylinders in which there is an unduly large range of temperature, or in which the changes of temperature are slow, owing to the small number of strokes made per minute. In such engines a part of the loss from these causes may, Mr. Willans thinks, be recovered by judicious steam jacketing, but even this is questionable. In the Willans engines there is no large range of temperature, and such changes of temperature as take place are extremely rapid; consequently, jacketing, it is held by the makers, would be of little or no advantage. Automatic variable expansion gear is not considered to be needed in the present instance.—*The Engineer.*

ABSOLUTE VACUUM AS A NON-CONDUCTOR, AND ITS BEARING ON ELECTRIC THEORIES.*

By Dr. P. H. VAN DER WEYDE.

THE historical exhibition which I furnished at the late American Institute fair contained several series which for want of space could not be separately shown, as would have been desirable, if space had permitted. In fact, everthing was to a great degree mixed up, for the reason referred to.

Among these series, electricity in vacuo formed a prominent and important feature, and because this is a subject so little understood and even misunderstood by the majority of electricians, and is also neglected in the textbooks, I felt induced to take this for my subject, when I was requested to address the society.

An additional reason was that it is of some practical importance, not so much in regard to its mechanical applications as for the understanding and explanation of a great number of natural phenomena.

I will treat the subject historically, and therefore begin with calling your attention to the experiments of Nollet, recorded in his little book published in Paris in 1753, and illustrated with carefully engraved figures. His experiments consisted in passing a current of static electricity through glass flasks, from which a large portion of the air had been previously removed by the air pump. He found that the electric current passed as a luminous stream which was very bright when the room was darkened, while luminous pencils were thrown off toward the sides of the flask, if they were touched by the fingers or any other conductor of electricity.

Some thirty years later a variation of this experiment was contrived, consisting of a strong glass tube of about two or three inches diameter and three or more feet long, provided with brass caps at each end, which could be conveniently attached to the air pump and exhausted. As the exhaustion proceeded, the rarefied air in the tube became a conductor of electricity, while this conductivity appeared to improve in proportion as the air was more exhausted. At last a regular stream of electricity was seen to pass through the tube, which stream resembled strikingly the luminous colored streams seen in the aurora borealis, wherefore such a tube was called the "aurora tube," and under that name is found in most philosophical collections.

This apparatus was exhibited at the fair, the exhibit consisting of an old historical air pump, made about 1780, with the aurora tube screwed on the top of it. A few other smaller devices of a similar nature were less conspicuous, and about them I wish only to remark, that, when using an ordinary air pump, it appeared that the conductivity of the air increased in proportion to the amount of exhaustion; hence the impression became prevalent that if we could only form a perfect vacuum, we would have the best of all conductors, and this idea is, unfortunately, even at the present day, shared by several prominent electricians who have not had the opportunity to keep themselves posted in regard to the discoveries made during the last few years, especially those made by Crookes, Gassiot, Spottiswoode, Gordon, and others.

I must not omit to mention that before the latter discoveries, Geissler, in Germany, began to furnish investigators with a great variety of glass tubes of various fanciful shapes, made of different kinds of glass and filled with various gases and vapors, exhausted by the air pump or by being heated, and then sealed up by the blow pipe, while platinum or aluminum wires were inserted at the extreme ends, so as to conduct the electric current through the rarefied gases inside. As those tubes exhibited a series of striking and beautiful phenomena, they became very popular, and no physical collection is considered complete without a set of such tubes. They give occasion to exhibit the auroral phenomena, and similar ones of the same character, without the trouble of continually working the air pump.

I had two sets of such tubes on exhibition at the fair; one was extra large, the tubes being three and four feet long, and another set of tubes as many inches in length, and which I shall have the pleasure to exhibit to you to-night, being much easier and safer to transport than large tubes.

I will now proceed to make a statement of the facts as they are. They are startling and difficult to explain without the knowledge of the new conceptions of Professor Crookes regarding the nature of matter in the four different conditions in which it presents itself to us.

The facts referred to are: The atmosphere in its ordinary condition is a very good non-conductor of electricity, provided it is perfectly dry and under a pressure equal to a mercurial barometric column of 760 millimeters or higher.

It is an important consideration, that if the air in which we live were a good conductor of electricity, man could never have become acquainted with electrical phenomena, as then static electricity could never have been collected, studied, and experimented with; as this form of electricity was the key to the other different forms, the latter would never have been discovered.

When rarefied by the air pump to a quarter of the normal pressure, the insulating qualities of air are not so good; and when reduced to a pressure of 10 or 20 millimeters, it is a good conductor and exhibits the phenomena referred to before. As this is about the limit attainable by an ordinary air pump, it is very natural that experimenters became possessed of the idea stated above, that the conductivity of the air would keep increasing as the exhaustion proceeded; but after the Sprengel mercurial air pump was invented, by which the air can be exhausted to a thousandth of a millimeter of mercurial pressure (which is about equivalent to one millionth part of ordinary atmosphere pressure), it was found that the capacity of the air to show the auroral phenomena in the usual way ceased.

The electric current then behaves in a very different manner, as it radiates in straight lines and cannot turn corners, so that when the tubes are bent it gives occasion for very striking and novel phenomena, which were first brought forward by Professor Crookes in the tubes which are known by his name.

The difference between the Geissler tubes and the Crookes tubes is, that in the first the vacuum is very imperfect. In the Crookes tubes it is about a thousand times better, while if we succeed in making the vacuum a million times better, the conductivity of the air ceases absolutely. To accomplish this we must aid the function of the Sprengel air pump by some chemical device which will remove the last remnant of air. It then becomes an absolute non-conductor, which ordinary atmospheric air is not, because it is possible to pass currents of high tension in the form of an electric spark through the densest and driest air. In the absolute vacuum, however, it is impossible to pass, over the space of a quarter inch, a spark which, when leaping through air, will be six or more inches long.

I exhibit here such a tube in which the two platinum wires are brought together within a distance of scarcely a quarter inch. In this tube a vacuum did exist so perfect that it was impossible to pass a spark through, which through air would leap over a distance of more than six inches. I found that the spark would rather pass over the outside of the tube for that distance than go through the interior. In order to satisfy myself that no trace of electricity passed through the interior space of a quarter inch, I connected one of the platinum wires with a Leyden jar, wound a brass chain half way around the middle part of the tube, and connected this brass chain with the ground, in order to prevent any electricity from reaching the Leyden jar through the air along the outside, but I was not able to obtain the least trace of a charge in the Leyden jar. Later I increased the strength of the current more and more, until at last something happened in the tube which destroyed the vacuum; something volatilized, covering the sides of the glass interior with a blackish deposit, which may perhaps be platinum black—a thing which may not be impossible, if we consider that the electric discharge furnishes us the highest temperature which we can possibly produce by any means.

For more than twenty years I have preached this non-conductibility of a perfect vacuum, as it was proved by experiments with the Ruhmkorff coil, by De la Rive and Du Moncel.

It has not a little surprised me that the priority of this discovery is so remote as I found it to be, and that so important a fact as that of the non-conducting power of a perfect vacuum has been overlooked and ignored for nearly a century after it was proved by experiment.

It is also a fact known for more than a century by expert barometer makers, that the luminosity which shows itself in the dark in its vacuum, when a barometer is moved up or down in order to cause the mercurial column to oscillate in the same way, is only seen when the mercury has been boiled in the tube to a moderate degree; when the vacuum is made too perfect, it shows itself feebly, or not at all, the same as is the case when the vacuum is contaminated with watery vapors.

So much for facts; now for the theory which explains them, and for which we are indebted to Professor Crookes. It gives us an inside view of the nature of matter in the conditions in which it presents itself to us, and is based on the theory of Dalton, that all matter consists of an immense number of infinitesimal particles, called atoms, which are indestructible and in continual motion, which latter is also indestructible.

Astronomy teaches that in the planetary system we find a condition of things which are far beyond our ordinary conception based on our experience about things falling under the daily immediate observation of our senses. First, the distances at which the celestial objects are placed are immense in proportion to their size, stupendous as it appears to us. Secondly, they are in a continuous motion, which is indestructible. Every planetary system is to us a perfect "perpetuum mobile."

Modern chemistry teaches the same doctrine in regard to ultimate atoms, which constitute that which we call matter. First, the distances of these atoms are also very large in proportion to their size, which is infinitesimally small beyond our conception; secondly, these small particles or atoms are also in a continuous, everlasting motion, as indestructible as is the motion of the planetary bodies.

As a concise statement of the modern philosophical conceptions in regard to this subject, we say that, as the chemists of the past century proved that apparent destruction of matter was only a transmutation of form, so the physicists of the present century have proved that apparent destruction of motion is also merely a transmutation of form, a change in the mode of motion; mass motion changed into molecular motion, which reveals itself as heat, light, or electricity, or, *vice versa*, any of the latter forces into one another or into mass motion. Of this transformation the steam engine and the modern dynamo are forcible illustrations.

The great Swedish chemist, Berzelius, more than half a century ago expressed similar views, when he declared that the heat and light we see in an electric discharge, say in a stroke of lightning, is not the electricity itself. He states most explicitly that the restoration of the electrical equilibrium, which, when destroyed, gives rise to what we call electrical phenomena, causes the evolution of sudden light and heat in the bodies through whose medium this restoration of equilibrium takes place, which light and heat then radiates and diffuses itself according to the ordinary well known laws of radiation and convection.

Crookes, in order to explain the peculiar behavior of electric discharges through his highly exhausted tubes, teaches the doctrine that our conception of three states of matter, solid, liquid, and gaseous, is incomplete; he says that there is a fourth condition, which he calls radiant matter. He teaches as follows:

In solid bodies the atoms are in a state of rest; that is to say, as far as their relative position is concerned, but each atom oscillates to a greater or lesser degree. If the amplitude of the oscillation is small, we call the body cold; if the amplitude of the oscillation is large, we call the body hot; and in so far Crookes' theory agrees with what Tyndall has popularized in his well known work entitled "Heat as a Mode of Motion."

When the amplitude of the oscillations becomes so great that the atoms turn over and commence to rotate around their centers, the body reaches its melting point, and becomes a liquid. Therefore, in liquids the atoms are not rigidly fixed to certain positions, but can freely roll over one another, and this constitutes the difference between solids and liquids.

When the velocity of the rotation becomes greater and greater, we say that the liquid is becoming hotter; and when from some cause or other this motion is still further increased, a new set of phenomena begins. The atoms are projected into space, and in place of rotating they are propelled from the liquid, and also repel one another, and as millions upon millions exist in the small space of a cubic inch, collisions take place by billions, and the body enters in what we call the "gaseous" condition.

In considering the motion of the atoms of gaseous matter, we enter the other extreme of the conception of great and small. It appears that the number of atoms in one cubic inch of the common air we breathe is represented by a series of more than twenty figures, which particles or atoms are in constant continual collision, to the number of ten million per second, while the velocity is so great that, if moving in a straight line, they would pass through a space of eleven thousand feet in a single second, thus surpassing the velocity of sound ten times. This is the nature of the third or gaseous condition.

The fourth condition, attained by the Sprengel air pump, is called by Crookes radiant matter. It is reached when the exhaustion proceeds so far that there are so few atoms left as to make the collisions exceptional; then the atoms will move in straight lines, and, encountering no mutual hindrance to their motion, they will follow the laws of electric repulsion and *radiate* from the point charged with electricity; hence matter in this condition is called "radiant matter."

Now we come to the most interesting feature of our consideration, namely, the chemical device referred to above, and intended to remove this last trace of air; recourse is had to the strong chemical affinity of potash for carbonic acid. The exhausted tube is filled with carbonic acid gas and again exhausted, and this process repeated in order to make sure that no atmospheric air is left, but only very rarefied carbonic acid

* Lately read before the New York Electrical Society.

gas. A recess is connected with the tube undergoing the operation, in which recess is placed a small stick of pure caustic potash. This recess is heated by a spirit lamp, so as to drive out the carbonic acid which the potash may contain, and then the vacuum is again made. The last remnant of carbonic acid which the air pump cannot remove is then absorbed by the potash, when this is allowed to cool down. In this way the absolute vacuum is produced, through which no electric current can be made to pass.

The bearing of this fact is of the utmost importance in regard to our conception of the nature of electricity. It is generally admitted that the theory of the existence of a caloric fluid is erroneous, and that heat is merely a peculiar mode of motion, as referred to above, and this view is adopted, notwithstanding there is no experiment known serving to demonstrate that heat cannot be transmitted through a space absolutely devoid of all matter. Heat and light will both pass through a vacuum perfect enough to obstruct absolutely the passage of electricity. If there were such a thing as an electric fluid, it surely would pass through any empty space, and we are therefore driven to the conclusion that the presence of matter is as absolute a condition for the transmission of electricity as the presence of air is an absolute condition for the transmission of sound; and there is as little necessity to accept the hypothesis of the existence of an electric fluid as there is for the hypothesis of a sonorous or caloric fluid.

Air being the ordinary vehicle by which sonorous vibrations are transmitted, a proper degree of exhaustion will arrest this transmission, and any common air pump can be made to prove that sound is with difficulty transmitted through a partial vacuum, and not at all when the vacuum is somewhat nearer to perfection. This experiment is acknowledged to be intended for a demonstration that the molecules of the air are the media for transmitting sound, and that without such a medium there can be no sound, and that there exists no peculiar sonorous imponderable fluid which pervades the air, and should be the cause of sound transmission. When now we see that more highly rarefied air behaves toward electricity in exactly the same way as the lesser rarefied air behaves toward sound, namely, that at a certain degree of rarefaction the transmission becomes more imperfect and at a certain point stops entirely, we are driven to the conclusion that electricity as well as sound is merely a peculiar form of motion of ponderable matter.

The conventional method of calling electricity a fluid must be understood to be only for the sake of convenience in explaining the phenomena presented. An argument in favor of this custom is that electric currents behaved like water in two respects, namely, moving under greater or smaller pressure, and in greater or smaller quantities. What in water is called pressure or head is in electricity called electromotive force, and as hydraulic pressure can overcome great obstacles, so electromotive force overcomes great resistances. It is measured by a standard unit, which is properly called after the illustrious Italian who first invented apparatus which multiplied the small electromotive force of a galvanic couple, the column of Volta. The quantity discharged through a channel is measured by another standard, also very appropriately named after the great French investigator Ampere, who discovered the laws governing the mutual action and reaction of currents of great quantities.

That rarefied air is by no means so good a conductor as assumed by many, is proved by the fact that it requires a considerable electromotive force to pass it through.

I referred in the beginning of this paper to the application of the knowledge recently obtained in regard to the behavior of electricity in rarefied air and in vacuo for the purpose of explaining certain natural phenomena. These phenomena are principally the aurora borealis and australis, and especially those which are related to the immense enigmas which from time to time appear in the heavens, the comets, which alarm the ignorant.

DETECTION OF ALKALOIDS AFTER DEATH.

By Dr. PELLACANI.

IN a recent number of the *Rivista Sperimentale di Freniatria e di Medicina Legale*, Dr. Pellacani gives an account of some experiments which he made for the purpose of determining how long various poisonous substances resist putrefaction. It is obvious what an important bearing this question may have in medico-legal cases. The following was the method adopted: A fixed quantity of the poison having been introduced into a definite quantity of blood, the mixture was allowed to putrefy under favorable conditions of temperature. From time to time it was tested for the poison, the same method being carefully employed in each case. Physiological tests were used in the case of such substances as atropine, physostigmine, curarine, etc., and in other cases methods giving characteristic reactions were employed.

The poisons experimented with were for the most part vegetable alkaloids, which were introduced in a free state in the following proportions relatively to the blood: 0·10 in the case of physostigmine, atropine, pilocarpine, daturine, and digitalin, and 0·50 in the case of all other substances.

In this way Dr. Pellacani found that no trace of digitalin or santonin could be found in the putrid liquid after four months, while atropine, daturine, and physostigmine took thirteen months to disappear; at the end of that time there was still a trace of iodine. Morphine and picrotoxin gave signs of their presence after twenty seven months; aconitine and cicutine were still present in considerable quantities after thirty-four months, and veratrine was found at the end of thirty-nine months. As regards curarine, it remained unaltered for twenty eight months; but after thirty-nine months the physiological test gave a negative result, although the characteristic reaction still persisted, except with the sulphuric acid test. Dr. Pellacani considers that these experiments prove that putrefaction is not so rapidly destructive of vegetable poisons as has hitherto been believed. This is particularly the case with alkaloids.—*Brit. Med. Jour.*, July 21, 1888, p. 152; *Med. Chronicle*, Sptb.

To the foregoing abstract of Dr. Pellacani's paper may be added the results of researches on colchicine, by Dr. N. Obolonski (*Viertelj. f. ger. med.*, Jan., 1888), who found that colchicine, when present in small quantities (5 mgrms. in 500 grammes of organic substance), can be recognized with certainty. The alkaloid is of greater stability, and is not liable to decomposition even when mixed with organic substances in an advanced stage of putrefaction. The usual chemical processes for isolation do not produce any changes in the alkaloid. The best reagents for the detection of colchicine are nitric acid, which gives a violet color, and a mixture of nitric and sulphuric acids, which give a green changing to dark blue, violet, and yellow. Of these, nitric acid is the best.—*Am. Jour. Pharm.*

TIN.

By LEO VIGNON.

TIN, which has been precipitated by means of zinc from neutral solutions of stannous and stannic chlorides, is very readily oxidized. If exposed to the air for three or four days, it contains a quantity of hydrated stannous oxide, equal to the fourth or third of its weight. A relatively small quantity of stannous oxide mixed with metallic tin renders it infusible. If tin partially oxidized is heated in contact with the air, it burns without fusing. In a current of an inert gas globules of tin form and remain isolated without coalescing into a regulus. This phenomenon is analogous to that presented by mercury, which remains subdivided in presence of certain impurities.—*Comp. Rend.*

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